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AUTHOR Stowe, Robert C.
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ABSTRACT

Designed to assist in the study of techniques for and approaches to the evaluation of scientific research, this annotated bibliography of publications deals with qualitative and quantitative indicators of the quality of science. Entries are provided in the following categories: (1) bibliometric indicators of the quality of scientific research; (2) qualitative approaches to and more general works on research evaluation; (3) works dealing with science indicators; (4) forecasting and research priorities; (5) peer review; (6) quality and quantity in the history of science and philosophy; (7) education; (8) issues involving quantity and quality in particular disciplines (including social indicators, history, health, and policy evaluation); (9) sociology of science; (10) methodological papers and bibliographies; and (11) access of women to participation in scientific research. (ML)

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ANNOTATED BIBLIOGRAPHY OF PUBLICATIONS DEALING WITH QUALITATIVE AND QUANTITATIVE INDICATORS OF THE QUALITY OF SCIENCE

(Including a bibliography on the access of women to participation in scientific research.)

By Robert C. Stowe*

A Technical Memorandum of the Quality Indicators Project
(Principal Investigator: Gerald Holton)

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PREFACE

The following bibliography has been compiled for use by the Quality Indicators Project. However, in spite of its undoubted incompleteness in many respects, we have been persuaded to make it available to other scholars studying techniques for and approaches to the evaluation of scientific research. On a *quid pro quo* basis, we ask such readers to alert us to literature that should be included and to errors in the text.

Interest in this field has grown during the last decade for several reasons. National budgets for research have shrunk, or at least grown less quickly than they had previously, prompting inquiry into appropriate means to make choices between projects and programs requiring funding. Scientific research leads, by winding paths, to technological development and therefore to economic benefits; in times of economic turmoil demands are made to define the paths and therefore, it is hoped, maximize the benefits. The perception has become more widespread that scientific research, both in itself and through its technological fruits, can have harmful as well as beneficial effects for society. Concomitantly, the need has arisen for means to assess *a priori* the impact of research.

Also, it has become clear that women and minorities are underrepresented in the scientific community. Studies of this phenomenon, many of them performed by sociologists, often involve the determination of the quality of research and researchers. It is important to understand as fully as possible the strengths and weaknesses of the various approaches to such determinations in order that the desired ends--fair science and good science--be simultaneously achieved. (This project has in particular reviewed the literature dealing with women's participation, or lack of participation, in science. Much of this literature is listed in Section XI of the bibliography.)

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*Jefferson Physical Laboratory, Harvard University, Cambridge, Mass. 02138

Josiah Macy, Jr. Foundation. The distribution of this memorandum does not imply endorsement by either of these foundations.

INTRODUCTION

A. Other Bibliographies

In the four bibliographies listed below one may also find references to publications which address various aspects of science indicators or the evaluation of research. The four bibliographies are held in Project files.

We have attempted to list in these pages the more important citations from these bibliographies, but inevitably some will have been neglected. At many points we quote directly from another annotated bibliography, except for reference 3 immediately below. Each quote is accompanied by a reference to the original bibliography. The Abt Associates bibliography (reference 2 below) contains abstracts more detailed than have generally been attempted here and will therefore be valuable regardless of any overlap with our compilation.

1. "Citation analysis: An annotated bibliography," Susan Cozzens, et al., Institute for Scientific Information (May 1978).

> Includes 678 entries, explanatory introduction, and an index which interfiles authors and subjects. When the notes in the current bibliography quote from "Citation analysis" they cite the original as "Cozzens."

2. "Methods for the strategic evaluation of research programs: The state of the art--Annotated bibliography," Jonathan D. Hodgdon, Stephen J. Fitzsimmons, et al., Center for Science and Technology Policy Studies, Abt Associates, Inc. (March 15, 1985).

> Bibliography containing 47 entries with detailed annotation, organized under the following categories: 1. Bibliometric methods; 2. Economic and stochastic decision models; 3.Peer review and scoring methods; 4. [cross-national] Comparative studies; and 5. Other studies. In addition, the report includes a reprint of a non-annotated bibliography entitled "Documents collected for the federal research evaluation activities study" [of the George Washington University Program of Policy Studies in Science and Technology; see entry under Logsdon in Sec. II]. Accompanies "Methods for the strategic evaluation of research programs: The state-of-the-art (Analytical overview report)" by the same authors.

3. "Productivity of women in science," prepared by the Institute for Scientific Information (July 23, 1985).

> Two bibliographies culled from Sociological Abstracts and

SCISEARCH, respectively. The former is annotated and contains 49 entries; the latter is non-annotated and contains 111 entries. These compilations are available from the Institute for Scientific Information. The notes in the current bibliography do not quote from "Productivity of women in science."

4. "Scientometric analyses in physics: A bibliography of publication, citation and mobility studies," Jan Vlachy, Czechoslovak Journal of Physics, B35 (1985): 1389-1436.

A very comprehensive but non-annotated listing of about 950 publications. The bibliography is unusual in that somewhat more than 30% of the entries are from Eastern European or Soviet sources. The compiler, who is one of the world's experts in bibliometric assessment of research, offers a short but insightful introduction and a list of the major sources used, which includes a number of other useful bibliographies.

B. Location of Items

The name of the Quality Indicators Project file in which our copy of a paper is stored is indicated after the reference. For example, a particular citation may be followed by "file 'Citations'" or "file 'Priorities and Foresight'." References to books or longer documents are often followed by the term "Shelf" rather than by the name of a file. These, clearly, are physically stored on the shelves of the project office. A few papers and books are not held by the Project. These are usually followed by the name of a Harvard University Library (e.g. Widener, Cabot) and a call number (usually Library of Congress).

If the piece is also listed in one or more of the bibliographies referred to immediately above, one of the following three symbols may be found after a cite: COZZENS, ABT, or WOM. "COZZENS" means that the item is also listed in "Citation Analysis: An Annotated Bibliography" (reference 1 above); "ABT" means that the item is also in "Methods for the strategic evaluation of research programs: The state of the art--Annotated bibliography" (reference 2 above); "WOM" means that the item is also in the Sociological Abstracts search conducted by the Institute for Scientific Information (reference 3 above). Vlachy's bibliography (reference 4 above) has not been cross-referenced with the items in this compilation. We suspect, however, that almost all of the items in sections i-IV following, plus many more, are also listed in Vlachy's work.

C. Index/Organization of Items

Items are organized according to the following categories. These categories overlap, and a number of items are listed under more than one.

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I. Bibliometric indicators of the quality of scientific research....2

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A. Social indicators....61

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BIBLIOGRAPHY

i. CORE BOOKS

Elkana, Yehuda, et al., eds., Toward a Metric of Science (N.Y.: John Wiley & Sons, 1978). Shelf.

Includes papers by Thackray, Holton, Kochen, Griliches, Ziman (see Sec. II); Duncan, Price, Kruskal, Garfield, et al., Cole, et al., Zeisal, and Ezrahi (see Sec. III).

La Follette, Marcel Chotkowski, ed., Quality in Science (Cambridge, Mass.: MIT Press, 1982). Shelf.

Includes papers by Brooks, R.S. Morison, and Mazlish (see Sec. III); Branscomb, Prewitt, Yankelovich, Weingart and Bok (not noted separately); and shorter pieces by Senator Hatch and Congressmen Brown, Fuqua, and Walgren. With an introduction by Gerald Holton.

National Science Board, Science Indicators (Washington, D.C.: National Science Foundation, 1972, 1974, 1976, 1978, 1980, 1982, 1984).

Shils, Edward, ed., Criteria for Scientific Development: Public Policy and National Goals (Cambridge, Mass.: MIT Press, 1968). Shelf.

Collection of papers from Minerva by Weinberg, Maddox, Toulmin (see Sec. IV); Carter, Williams, Rottenberg, Polanyi, Dedijer, Moravcsik, and Salam.

U.S. Congress, Office of Technology Assessment, Research Funding as an Investment: Can We Measure the Returns? (Washington, D.C.: U.S. Government Printing Office, 1986).

Literature review of bibliographic and economic approaches to evaluating scientific research. Concludes that quantitative methods for assessing the returns on research are of limited use, especially for research conducted by government agencies, and that qualitative approaches, especially peer review, are essential for such assessments.

I. Bibliometric indicators of the quality of scientific research

A. Citations and publications as indicators of quality

Bayer, Alan E. and Folger, John, "Some correlates of a citation measure of productivity in science," Sociology of Education, 39 (1966): 381-390. File "Citations." COZZENS.

> Authors' abstract: "The Science Citation Index provides an easy way to derive criterion measures of scientific accomplishment. Measures derived from citation counts, the principle criterion, have high face validity. These criterion measures are found to have a low but positive correlation with the quality of scientists' graduate education [based on Cartter report] and no relation to his measured I.Q. score."

Braun, Tibor and Bujdosó Ernö, "The growth of modern analytical chemistry as reflected in the statistical evaluation of its subject literature," special issue of CRC Critical Reviews in Analytical Chemistry, 13 (March 1982): 223-312. File "Citations."

> Braun is one of the founders of the journal Scientometrics and this is his most ambitious scientometric study. He and his colleague present and analyze data on the volume, growth, "aging," and distribution (with respect to countries, languages, topics, and other criteria) of the analytical chemistry literature. They also investigate publication and citation patterns in analytical chemistry journals and of groups of scientists in the field.

Broadus, Robert N., "An investigation of the validity of bibliographic citations," Journal of the American Society for Information Science, 34 (March 1983): 132-135. File "Citations."

> Author's abstract: "[E.O.] Wilson, in his famous work, Sociobiology, The New Synthesis..., makes reference to a pair of articles by W.D. Hamilton, but misquotes the articles' title. No less than 148 later papers make reference to both Wilson's book and Hamilton's articles, by title. Thus, there is provided an opportunity to test the charge, made by some critics, that writers frequently lift their bibliographic references from other publications without consulting the original sources. Although 23% of these citing papers made the same error as did Wilson, a further perusal of the evidence raises considerable doubt as to whether fraudulent use was intended."

Bruer, John T., "Methodological rigor and citation frequency in patient compliance literature," American Journal of Public Health, 72 (Oct. 1982): 1119-1123. File "Citations."

> Author's abstract: "An exhaustive bibliography which assesses the methodological rigor of the patient compliance

literature, and citation data from the Science Citation Index (SCI) are combined to determine if methodologically rigorous papers are used with greater frequency than substandard articles by compliance investigators. There are low, but statistically significant, correlations between methodological rigor and citation indicators...The correlation is not strong enough to warrant use of citation measures as indicators of rigor on a paper-by-paper basis. The data do suggest that citation measures might be developed as crude indicators of methodological rigor..."

Bruer, John T., "Methodological rigour and review citation frequency in patient compliance literature," Journal of Documentation, 39 (Sept. 1983): 166-170. File "Citations."

An extension of the research discussed in the paper cited immediately above, examining the relationship between methodological rigor and citation frequency in review articles.

Bruer, John T., "Methodological quality and citation frequency of the continuing medical education literature," Journal of Documentation, 41 (Sept. 1985): 165-172. File "Citations."

Author's abstract: "Bibliometric analysis of research reports in continuing medical education that were evaluated for their methodological quality is used to assess the relation between methodolgical rigour and citation frequency. There is a positive, significant but low correlation between rigour and citation, and evidence that rigorous work will be cited independent of where the article is published. There is no strong evidence that study design is correlated with subsequent citation...In certain cases citation measures might be used as guides to or indicators of methodologically rigorous reports."

Bujdosó, Ernö and Braun, Tibor, "Publication indicators of relative research efforts in physics subfields," Journal of the American Society for Information Science, 34 (March 1983): 150-155. File "Citations."

Uses publication counts to compare research "activity" across subfields in physics and across countries.

Castro, Barry, "The scientific opportunities foregone because of more readily available federal support for research in experimental than theoretical physics," Journal of Political Economy, 76, No. 4 (July/August 1968): 601-614. File "Citations." COZZENS.

"It is hypothesized that relatively easy federal support for experimental work causes physicists to avoid theoretical problems that have greater potential scientific utility...Such foregone scientific opportunities are regarded as opportunity costs of federal support for physics

research, and it is the measurement of these costs that is this paper's basic subject matter. The net opportunity costs of federal research cannot be measured in money terms, and the physics literature is used to provide an alternative source of measurement...any excessive emphasis that federal science-supporting agencies have placed on experimental physics should be reflected in a relatively low average frequency of citation to experimental articles and a relatively high average frequency of citation to theoretical articles." The hypothesis is confirmed.

Chang, K.H., "Evaluation and survey of a subfield of physics: Magnetic resonance and relaxation studies in The Netherlands," (Utrecht, The Netherlands: Stichting F.O.M., report no. FOM-37175, 1975). Shelf.

Author's abstract: "A survey of the Dutch activities...and the significant publications in the subfield [are presented]...it is concluded that the various approaches which have been followed to evaluate the impact of the particular studies, viz. interviews with experts, scanning of textbooks, searching for awards, analyzing the Science Citation Index, etc., have yielded non-contradictory results...A new procedure to analyze data obtained from the Science Citation Index is discussed in the appendix." Includes a section in the concluding chapter entitled "Evaluation: citations, a measure for quality?" Although the report emphasizes the value of citation analysis, it explores in detail the problems with the use of this set of techniques.

Chang, Hans and Dieks, Dennis, "The Dutch output of publications in physics," in Le Pair and Volger, eds., Physics in The Netherlands, Vol. II (Utrecht: Foundation for Fundamental Research on Matter, 1982): A3-A18. Shelf.

Is accompanied by a research note on published productivity in twenty countries, describing available citation indexes and based on work of D.J. de S. Price.

Cohen, J.E., "Publication rate as a function of laboratory size in a biomedical institution," Scientometrics, 2, No. 1 (1980): 35-52. File "Citations."

Statistical study of the publication output of a research group at Rockefeller University. Finds that output of group is approximately proportional to number of individuals in the group.

Cole, Jonathan R., "Patterns of intellectual influence in scientific research," Scoiology of Education, 43 (1970): 377-403. Not in files. COZZENS.

Cozzens' abstract: "This paper challenges the 'Ortega hypothesis'; that is, the assumption that science progresses

only through the cumulative efforts of the whole community. Using citation counts to determine 84 university physicists' best papers as of 1965, the intellectual input to these papers is then traced by looking at the citations contained in them. Citation is then used as an indicator of quality, and as a documentation for intellectual influence and use. The study indicates that physicists at all strata disproportionately cite the work produced by members of the most distinguished departments."

Cole, Jonathan R. and Cole, Stephen, "The Ortega hypothesis," Science, 178 (October 27, 1972): 368-374. File "Citations." COZZENS.

Supports the theory that science operates on the basis of universalistic criteria rather than elite control. The authors find that the "quality of published research [as measured by citation counts] explains more variance than any other variable on several types of recognition."

Cole, Stephen, "The growth of scientific knowledge: Theories of deviance as a case study," in L.A. Coser, ed., The Idea of Social Structure: Papers in Honor of Robert K. Merton (N.Y.: Harcourt Brace Jovanovich, 1975). Paper in File "Sociology of Science"; book in Social Relations Library HM24 .I34. COZZENS.

Uses Merton's theory of deviance (social structure and anomie) and subsequent literature on deviance "as a research site to explore the social processes through which knowledge grows and ideas change." Cole builds on the work of Thomas Kuhn, who "has concluded that, ultimately, the process through which ideas change and develop can be understood only through sociological analysis." The author outlines "some of the problems raised by Kuhn and then, using the field of deviance research as an example," illustrates "how we might go about empirically investigating a few of these problems." This investigation relies on citation analysis.

Cole, Stephen, "Professional standing and the reception of scientific discoveries," American Journal of Sociology, 76 (Sept. 1970). File "Sociology of Science." COZZENS.

Tests the hypothesis that "if the Matthew Effect were to operate, the reception of papers of equal quality should be influenced by the location of their authors in the stratification system." Measures quality with citations. Cole finds that, for the most part, the hypothesis is not supported by the data.

Cole, Stephen and Cole, Jonathan R., "Scientific output and recognition: A study in the operation of the reward system of science," American Sociological Review, 32 (June 1967): 378-390. File "Citations." COZZENS.

Studies "The relationship between the quantity and quality

of scientific output of 120 university physicists. Although these two variables are highly correlated, some physicists produce many papers of little significance and others produce a few papers of great significance." Quality is measured by citations, using SCI.

Cole, Stephen, et al., "Measuring the cognitive state of scientific disciplines," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 209-251. Shelf.

From the authors' introduction: "Problems occur in interpreting the indicators presented in SI-72...Two fields appearing to be similar on a set of quantitative indicators may be qualitatively in quite different stages of development and exhibit very different cognitive structures...Clearly we need indicators of the qualitative as well as the quantitative aspects of science." However, the indicators of qualitative aspects of science used in the paper are themselves quantitative (publications and citations).

Garfield, Eugene, "Are the 1979 prizewinners of Nobel class?" Current Contents (Sept. 22, 1980): 5-13. File "Citations."

Citation analysis of 1979 Nobel winners. S. Weinberg was found to have an unusually high number of citations to his work.

Garfield, Eugene, "The awards of science: Beyond the Nobel Prizes--Part 2: The winners and their most cited papers," Current Contents (Dec. 10, 1984): 3-17. File "Citations."

Citation analysis of the work of winners of 56 prestigious scientific prizes, with qualitative discussion of important papers.

Garfield, Eugene, Citation Indexing--Its Theory and Application in Science, Technology, and Humanities (N.Y.: John Wiley & Sons, 1979). Cabot Science Library Z697 .S5 .G37.

Garfield's summary of two decades of work in the field. Chapters on the use of citation indexing in patent work, literature searches, science management, history and sociology of science, and "mapping the structure of science" (co-citation analysis). A final chapter examines the difficulties and dangers associated with the use of citation analysis for the evaluation of individual scientists. Includes a foreward by Robert K. Merton.

Garfield, Eugene, Essays of an Information Scientist, Vols. 1-7 (Philadelphia: ISI Press). Volumes compile essays from the years 1962-73, 1974-76, 1977-78, 1979-80, 1981-82, 1983, 1984. Shelf.

Include a great many essays on citation analysis. With

Forewords by Joshua Lederberg, Derek J. de Solla Price, Harriet Zuckerman, Robert K. Merton, V.V. Nalimov, and Gerald Holton.

Garfield, Eugene, "How to use citation analysis for faculty evaluations, and when is it relevant?" Parts I and II, Current Contents (Oct. 31, 1983): 5-13; (Nov. 7, 1983): 5-14. File "Citations."

Proposes a use of citations which is quite controversial. Suggests that citation analysis might be useful in identifying colleagues who are competent to judge a candidates' work. Goes beyond this, however, to discuss quantitative approaches to measuring impact of papers, using citations of various kinds.

Garfield, Eugene, "The 100 most-cited papers ever and how we select 'Citation Classics'," Current Contents (June 4, 1984): 3-9. File "Citations."

Garfield notes that "we use citation frequency as the first criterion in selcting 'Citation Classics'," then goes on to elaborate.

Garfield, Eugene, "Price's citation cycle," Current Contents (Sept. 29, 1980): 5-7. File "Citations" (with Price).

Personal and intellectual biography of Derek de Solla Price. See also Price, "Citation cycle" (Sec. I.A).

Garfield, Eugene, et al., "Citation data as science indicators," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: WIley, 1978): 179-207. Shelf.

Includes discussions of co-citation and bibliographic coupling, the social and cognitive structure of science, and models of scientific research.

Goffman, William, "A pragmatic approach to literature selection," in K.S. Warren, ed., Selectivity in Information Systems: 117-143. (See Sec. II.).

Discusses an approach to libraries' selection of journals using co-citation maps (of journals, not authors).

Gordon, Michael D., "How authors select journals: A test of the reward maximization model of submission behavior," Social Studies of Science, 14 (1984): 27-43. File "Citations."

Tests the hypothesis that scientists choose journals to which to submit their papers based on expected rewards. Finds that hypothesis is not supported, but rather scientists choose journals on the basis of the audiences the journals reach.

Griffith, Belver C., et al., "The aging of scientific literature: A citation analysis," Journal of Documentation, 35 (Sept. 1979): 179-196. File "Citations."

The authors study various mathematical models of the manner in which use of scientific documents and journals declines over time. Their practical aim is to assist librarians in managing collections. They find that a model developed by B.C. Brookes conforms well with their citation data, with some caveats, including the observation that "Aging depends not merely on the material itself, but [also on] its user, and a single journal may be aged very differently by different user communities."

Inhaber, H. and Przednowek , K., "Quality of research and the Nobel Prizes," Social Studies of Science, 6 (1976): 33-50. File "Citations." COZZENS.

Statistically analyzes citation rates and changes in citation rates in an attempt to measure the "halo effect" in Nobel winners. Compares latter with scientists elected to the NAS. Finds that prestige and reputation have something to do with rise in citations after receiving prize. See also piece by Kppers, et al., (Sec. II.) which studies the Nobel nominating process in a qualitative manner.

Knudsen, Dean D. and Vaughan, Ted R., "Quality in graduate education: A re-evaluation of the rankings of sociology departments in the Cartter report," The American Sociologist (Feb. 1969): 12-19. File "Education."

Criticizes the Cartter report for its "subjective evaluations" and attempts to discern the correlation between these and more "objective indicators." The objective indicator used is publications and the authors find that the ranking of the best departments so indicated corresponds closely with that of the Cartter report, while the ranking of departments of lesser quality does not correlate well. See also W.J. Moore (Sec. I.A), Bayer and Folger (Sec. I.A), and Beyer and Snipper (Sec. VII).

Lawani, Stephen M. and Bayer, Alan E., "Validity of citation criteria for assessing the influence of scientific publications: New evidence with peer assessment," Journal of the American Society for Information Science, 34 (January 1983): 59-66. File "Citations."

Authors' abstract: "This article reviews the principle correlational studies employing citation counts as criterion measures for assessing the impact of scientific scholarship. The rationale and limitations of such measures and studies are discussed. New evidence on the validity of citation criteria is presented based on a sample of 870 cancer research papers...Results consistently show that highly rated papers are more highly cited over the ensuing five

years after publication, or when controls are introduced for self-citations, for the influence of listing in the yearbook, and for language and country of authorship. The implications of results are discussed."

Lewin, J., "A quantitative and qualitative case study analysis of scientific productivity in agricultural research," Israel Journal of Agricultural Research, 22 (1972): 129-139. Not in files. COZZENS.

Cozzens' Abstract: "The pre-1971 publication output of a group of 37 soil scientists...are analyzed in relation to the age of the research group. A steady increase in publication output with age is noted...A maximum [mean citation frequency] was found between 20-25 papers per scientist...Rather low correlation was found between the status of a journal...and citation frequency. However, the number of citations a paper received was found to be highly correlated to its rating by a peer review process."

Lightfield, E. Timothy, "Output and recognition of sociologists," The American Sociologist, 6 (May 1971): 129-133. File "Citations." COZZENS.

Quantity of output measured by numbers of papers; quality by citations.

MacRae, Duncan Jr., "Growth and decay curves in scientific citations," American Sociological Review, 34 (Oct. 1969): 631-635. File "Citations."

Uses an "exponential model," extending earlier work of Price (see Little Science, Big Science, Sec. I.A.), to separate the effects of growth of the literature and selection practices favoring more recent articles on citation. One finding is that "citations in sociology tend to refer to older articles than those in the natural sciences."

MacRoberts, Michael H. and MacRoberts, Barbara R., "The negational reference: Or the art of dissembling," Social Studies of Science, 14 (1984): 91-94. File "Citations."

Discusses possible reasons for the unexpected paucity of critical references in scientific literature and techniques which may be used to criticize implicitly.

Martin, Ben R., Irvine, John, and Crouch, David, "Science indicators for research policy: A bibliometric analysis of ocean currents and protein crystallography," University of Sussex, Science Policy Research Unit, Occasional Paper No. 23 (1985). Copy without appendices in File "Martin/Irvine"; complete copy in Kennedy School of Government Library, Science Policy Collection.

Martin and Irvine attempt to extend their methods of

evaluating research performance of laboratories or institutes (see entries in Sec. II under Martin or Irvine) to sub-disciplines within countries as a whole. Because of the size and cost of the undertaking, the authors abandon the use of peer review and rely exclusively on "numbers of publications, numbers of citations, and a citation-based measure of the scientific 'influence' of research" (p. 14).

Merton, Robert K., Foreword to E. Garfield, Citation Indexing: Its Theory and Application in Science, Technology, and Humanities (N.Y.: John Wiley & Sons, 1979). Cabot Science Library Z697 .S5 .G37. Reprinted in Current Contents, July 9, 1979: 7-10. File "Citations."

Review of citation analysis from the point of view of sociology of science.

Moed, H.F., et al., "The use of quantitative data for the measurement of university research performance," in W. Callebaut, et al., eds., George Sarton Centennial (Ghent, Belgium: Communication and Cognition, 1984). File "Citations."

Summary of research on "quantitative, literature-based... indicators as tools for university research policy." The study was prompted by "a drastic change of the allocation system at the University of Leiden." Two faculties within the university were evaluated, and the faculty members interviewed, but the results are not presented here.

Moore, William J., "The relative quality of graduate programs in economics, 1958-1972: Who published and who perished," Western Economic Journal (1973): 1-23. File "Education."

Uses rather elaborate mathematical models to find that publication rates are highly correlated with the Cartter report's rankings. See also Knudsen and Vaughan (Sec. I.A) and Beyer and Snipper (Sec VII).

Mullins, Nicholas C., Hargens, Lowell L., et al., "The group structure of co-citation clusters: A comparative study," American Sociological Review, 42 (Aug. 1977): 552-562. File "Citations."

Uses "block modeling of data from a sociometric questionnaire" to "analyze the patterns of social structure shown by authors of two highly cocited clusters of biological-science papers." The two groups show distinct differences. See also Shinn paper in Sec. IX.

Narin, Francis, Evaluative Bibliometrics: The Use of Publication and Citation Analysis in the Evaluation of Scientific Activities Report by Computer Horizons, Inc., Cherry Hill, N.J., to the NSF (1976). Document on microfiche in file "Citations." ABT.

Abstract from Abt Associates' Methods for the Strategic Evaluation of Research Programs (Bibliography) (p. 10; see

introduction): "This report examines extensively publication and citation analysis as a means of assessing scientific activity. It examines three major aspects of bibliometrics: 1) its historical development, 2) the numerous empirical studies that have been undertaken on the validity of evaluative bibliometrics, and 3) the 'influence methodology,' or the procedure for calculating individual journal influence...In summarizing the results of two dozen comparative studies, the author reports: 'These studies all tend to show that literature- based measures of the quality and quantity of scientific output correlate positively with non-literature measures. Peer evaluation of the eminence of scientists and of scientific institutions are almost always correlated with both citation and publication measures...' The author's report [also] points to some of the problems inherent in evaluative bibliometrics."

Narin, Francis, et al., "Inter-relationships of scientific journals," Journal of the American Society for Information Science, 23 (1972): 323-331. Not held in files. COZZENS.

From Cozzens' abstract: "The patterns of cross-citing among 275 journals in mathematics, physics, chemistry, biochemistry, and biology are 'mapped,' showing clear boundaries between fields and sub-fields...These maps support the intuitive hierarchy of fields: math to physics to chemistry to biochemistry to biology."

Narin, Francis and Carpenter, M.P., "Further development of indicators of the quantity and quality of the scientific literature," Amendment No. 4 to report NSF-C627 (Cherry Hill, N.J.: Computer Horizons, Feb. 1974). Not held in files.

Narin, Francis and Carpenter, M.P., "National publication and citation comparisons," report NSF-627 (Cherry Hill, N.J.: Computer Horizons, May 1974); version with same title published in Journal of the American Society for Information Science, 26 (March-April 1975): 80-93. JASIS version in File "Citations."

The paper describes the authors' development of citation and publication indicators for the NSF's first Science Indicators volume (1972). Compares publication and citation counts (per paper) across countries using data from the Science Citation Index and abstracting services.

Price, Derek de S., "The citation cycle," Current Contents, 12 (Sept. 29, 1980): 8-20. File "Citations."

Develops a model of scientific progress based on "an interlocking metabolic complex of bibliometric (and scientometric) parameters in a comprehensive and integrated structure after the manner of the Nitrogen Cycle and other such paraphernalia beloved of organic chemists and ecologists." See also Garfield comments on the model (Sec. I.A).

Price, Derek de Solla, "A general theory of bibliometric and other cumulative advantage processes," Journal of the American Society for Information Science, 27 (Sept.-Oct. 1976): 292-306. File "Citations." COZZENS.

Price develops a relatively elaborate mathematical model for evaluating cumulative advantage processes in the scientific community, which would in principle use bibliometric data.

Price, Derek J. de Solla, Little Science, Big Science (N.Y.: Columbia University Press, 1962). Cabot Science Library Q171 .P9464. COZZENS.

Cozzens' abstract: "The exponential law of scientific growth is demonstrated for several social dimensions. The logistic character of the curves for publishing, numbers of Ph.D.'s, etc. indicate that the U.S. is at the end of its exponential growth period and its rate should begin to decline relative to other countries. As Price's emphasis is primarily on statistical bibliography, discussion of citation is limited..."

Price, Derek J. de Solla, "Networks of scientific papers," Science, 149 (July 30, 1965): 510-515. File "Citations." COZZENS.

Takes into account the time elapsed between publication of a paper and citation of that paper, as well as the numbers of citations between papers. Uses the data to map, in a preliminary way, "research fronts," and suggests that "with such a topography [of research fronts] established, one could perhaps indicate the overlap and relative importance of journals and, indeed, of countries, authors, or individual papers by the place they occupied within the map, and by their strategic centralness within a given strip [or portion of a research front]."

Price, Derek J. de Solla, "The science of scientists," Medical Opinion and Review, 1, No. 10 (1966): 88-91, 94-97. Not in files. COZZENS.

From Cozzens' abstract: "The development of scientific laws about the nature of science begins with the recognition of the scientific paper as the basic unit of scientific structure...Because of this, citation patterns can reveal aspects of this structure..."

Price, D.J.d.S. and Gursey, S., "Studies in scientometrics, 1: Transience and continuance in scientific authorship," and "Studies in scientometrics, 2: The relation between source author and cited author populations," International Forum on Information and Documentation, 1, No. 2: 17-24; No. 3: 19-22 (1976). Not in files. COZZENS.

From Cozzens' abstract: "A statistical model is created which

describes the basic structure over time of the publishing population of scientists...[The] model...is extended...and indicates a high correlation between the few prolific authors and the few highly cited ones."

Roche, Thomas and Smith, David Lewis, "Frequency of citations as criterion for ranking of departments, journals, and individuals," Sociological Inquiry, 48, No. 1 (1978): 49-57. File "Citations."

Attempts to measure the quality of sociology departments. Builds on earlier work which suggests that the Science Citation Index would be valuable in performing this task. Has a very useful bibliography of the sociological literature on citation analysis.

Schubert, A. and Braun, Tibor, "Some scientometric measures of publishing performance for 85 Hungarian research institutes," Scientometrics, 3 (Sept. 1981): 379-388. MIT Dewey Library.

Authors' abstract: "Values of and correlations between some measures of publishing performance, scientific manpower, and citation impact were compared across" several research fields.

Stern, Nancy, "Age and achievement in mathematics: A case study in the sociology of science," Social Studies of Science, 8 (1978): 127-140. File "Citations."

Provides evidence that citations are a "crude indicator of quality of work in mathematics," but that "age explains very little, if anything, about productivity" or quality of work (i.e. young mathematicians are not more likely to produce highly cited papers).

Vlachy, Jan, "Physics journals typology, group rankings by citation and immediacy," Czechoslovak Journal of Physics B, 35 (1985): 589-592. File "Citations."

These and other entries for Vlachy are brief essays whose titles are self-explanatory.

Vlachy, Jan, "Priority choice and research front specialties in physics," Czechoslovak Journal of Physics B, 34 (1984): 95-98. File "Citations."

Vlachy, Jan, "Publication image of European physics," Czechoslovak Journal of Physics B, 34 (1984): 891-894. File "Citations."

Vlachy, Jan, "Research fronts in physics 1983," Czechoslovak Journal of Physics B, 34 (1984): 171-174. File "Citations."

Vlachy, Jan, ed., "Scientometric Analysis in Physics," special issue of the Czechoslovak Journal of Physics, B 36, No. 1 (1986). Shelf.

Forty-six papers on the evaluation of science, most of which focus on bibliometric methods. The authors, from 13 countries, include many of the world's experts on the evaluation of research. Vlachy offers an introduction and guide to the volume, with 186 references. A subject index is included.

Vlachy, Jan. "World physics publication output--country distribution and trends," Czechoslovak Journal of Physics B, 35 (1985): 705-708. File "Citations."

White, Howard D. and Griffith, Belver C., "Author cocitation: A literature measure of intellectual structure," Journal of the American Society for Information Science, 32 (May 1981): 163-171. File "Citations."

From the authors' abstract: "It is shown that the mapping of a particular area of a science...can be done using authors as units of analysis and the cocitations of pairs of authors as the variable that indicates their 'distances' from each other. The analysis assumes that the more two authors are cited together, the closer the relationship between them."

Zunde, P. and Slamecka, V., "Predictive models of scientific progress," Information Storage and Retrieval, 7 (1971): 103-109. Not in files. COZZENS.

From Cozzens' abstract: "The authors describe the use of Markov chain probability analysis to develop a model of long-run scientific development..." using in part citation patterns. "The model predicts...a general movement of activity from science and technology to social science disciplines."

B. Critiques of citation analysis

Bavelas, Janet Beavin, "The social psychology of citations," Canadian Psychological Review, 19 (April 1978): 158-163. File "Critiques of Citation Analysis."

Suggests that scholars cite other scholars "both because of scholarly impact and also...to show that we know the pertinent works in the area." Thus, citation counts may "measure social consensus as well as, and indistinguishably from, scholarly impact." The paper is basically critical of quantitative measures of quality of research, but advocates thinking for oneself rather than a complete return to the 'old boy network.'

Borenius, G. and Schwartz, S., "Remarks on the use of citation data in predictive models of scientific activity," Information Storage and Retrieval, 8 (1972): 171-172. Not in files. COZZENS.

From Cozzens' abstract: "...examines the assumptions

necessary to the use of the Markov chain predictive model of scientific activity." (See Zunde and Slamecka, Sec. I.A.) The authors discuss problems with this approach, which relies on certain forms of citation analysis.

Brooks, Terrence A., "Private acts and public objects: An investigation of citer motivations," Journal of the American Society for Information Science, 36 (July 1985): 223-229. File "Citations."

Empirical study of citer motivations. Finds that authors in both the humanities and the sciences used citations largely to "persuade," though the patterns of motivations between the two sets of disciplines varies greatly. "This is preliminary evidence that citer motivations cannot be treated as an undifferentiated whole; the specific rankings of citer motivations may differ by subject area. Less tenable now are simple and rational motivational models [such as those of Price, et al.; see references p. 227]."

Chubin, Daryl, "On the use of the Science Citation Index in sociology," American Sociologist, 8 (November 1973): 257-267. File "Critiques of Citation Analysis." COZZENS.

Although Chubin feels that citation analysis as such is a useful tool for sociologists in assessing the quality of research, he argues that sole reliance on the SCI may result in badly biased data, especially for fields "like sociology." He concludes that the main problems with the SCI are that it indexes only recent journals in sociology (but recall that this article was written in 1973), it does not account for widespread collaboration in the field, and it does not index second, and usually junior, authors.

Cole, Jonathan and Cole, Stephen, "Measuring the quality of sociological research: Problems in the use of the Science Citation Index, American Sociologist, 6 (February 1971): 23-29. File "Critiques of Citation Analysis." COZZENS.

The Coles discuss 9 potential problems with the SCI but conclude that "Nevertheless, the value of using them [citation counts] as rough indicators of the quality of a scientist's work should not be overlooked."

Duston, B. and Corbett, J.W., "Citation index mixleading," letter, Physics Today, 29, No. 9 (Sept. 1976): 89. File "Critiques of Citation Analysis."

Points out that different fields of physical science (and mathematics) have different citing norms, making comparisons between scientists in different fields problematic.

Endler, Norman S., "Beyond citation counts: Developing research profiles," Canadian Psychological Review, 19 (April 1978):

152-157. File "Measuring Output."

Author's abstract: "Recent studies using...SCI publication and citation counts as indices of productivity and scholarly impact are reviewed. The advantages and limitations of this method of asessing scholarship were discussed. Finally, a more broadly based research profile was outlined." The profile weights various types of publications and addresses.

Fox, Mary Frank, "Publication productivity among scientists: A critical review," Social Studies of Science, 13 (1983): 285-305. File "Critiques of Citation Analysis." ABT.

A review of literature on scientific productivity, written by a sociologist. Discusses three types of explanations for variations in productivity: 1/ individual-level characteristics; 2/ environmental location; and 3/ feedback process of cumulative advantage and reinforcement.

Garfield, Eugene, "Uses and misuses of citation frequency," Current Contents (October 28, 1985): 3-9. File "Citations."

Detailed analysis of the topic.

Gilbert, G. Nigel, "Referencing as persuasion," Social Studies of Science, 7, No. 1 (Feb. 1977): 113-122. File "Sociology of Science." COZZENS.

The author considers "scientific papers as 'tools of persuasion.' A scientist who has obtained results which he beleives to be true and important has to persuade the scientific community...to share his opinions of the value of his work. For it is only when some degree of consensus has been achieved that his research findings will be transformed into scientific knowledge."

Lindsey, Duncan, "Production and citation measures in the sociology of science: The problem of multiple authorship," Social Studies of Science, 10 (May 1980): 145-162. File "Critiques of Citation Analysis."

Concludes that neglect of multiple authorship in assessing research output introduces "intolerable error" and "often profoundly influence(s) substantive interpretation."

Long, J. Scott, et al., "The problem of junior-author papers in constructing citation counts," Social Studies of Science, 10 (May 1980): 127-43. File "Critiques of Citation Analysis."

Investigates in some detail the methodological pitfalls associated with using citation indices which list only first authors.

Moravcsik, Michael J., "Measures of scientific growth," Research Policy, 2, No. 3 (Oct. 1973): 266-276. File "Critiques of

Citation Analysis." COZZENS.

"Numbers of publications and citation ratings have recently been used as measures of scientific growth. The present paper discusses a number of presumed weaknesses of these measures. First, a distinction is made among scientifc activity, scientific productivity, and scientific progress. Then it is suggested that the above measures might depend on the particular field of science, on the speed whereby research front information becomes archival, on the phenomenon of wrong papers and 'also ran papers, on the geographical differences in communication patterns, on whether we want to measure activity, productivity, or progress, and on the temporal variations in scientific communication patterns. Though some examples are given, the quantitative substantiation of the proposed effects must await further research"

Moravcsik, Michael J. and Murugesan, P., "Some results on the function and quality of citations," Social Studies of Science, 5 (1975): 86-92. Not in files. COZZENS.

From Cozzens' abstract: "...references from...physics articles...are categorized as: conceptual or operational, organic or perfunctory, evolutionary or juxtapositional, and confirmative or negational...The large number of perfunctory citations (41%) raises serious doubts about the use of citation as a quality measure..." See also the literature review on citation context analysis by H. Small in Sec. I.C.

Morman, Edward T., "Citation analysis and the current debate over quantitative methods in the social studies of science," 4S (Society for Social Studies of Science) Newsletter, 5 (Summer 1980): 7-13. File "Critiques of Citation Analysis."

Intellectual history of the debate over the appropriateness of citation and co-citation analysis in the history of science. Focusses on Price, Garfield, and the Coles on the one hand, and Edge (see Sec. VI.) on the other (though other authors are discussed.) Short but very useful set of references.

Porter, Alan L., "Citation analysis: Queries and caveats," Social Studies of Science, 7, No. 2 (May 1977): 257-267. File "Critiques of Citation Analysis." COZZENS.

Review of the value of citations and methodological problems with their use.

Pragier, G. and Ronayne, J., "Criticism of the use of citation analysis in studying the science-technology relationship," Journal of Chemical Information and Computer Science, 15 (1975): 155-157. Not in files. COZZENS.

The authors discuss problems with assessing the effect of

academic research on industrial innovation using citation analysis.

Satariano, William A., "Journal use in sociology: Citation analysis versus readership patterns," Library Quarterly, 48 (1978): 292-300. File "Measuring Output."

Author's abstract: "This paper examines the hypothesis that citation patterns parallel readership patterns in sociology." He finds that "[C]itation patterns reflect a cross-disciplinary focus that is not found in the journals most often read. Further, citation studies underestimate the usefulness of popular social science periodicals and specialty and regional journals in sociology."

Thorne, Frederick C., "The Citation Index: another case of spurious validity," Journal of Clinical Psychology, 33 (October 1977): 1157-1161. File "Critiques of Citation Analysis."

An impressionistic account of a number of what the author sees as severe problems with citation analysis. Citation analysis itself is termed "One of the most amazing pseudoscientific popularity contests..."

C. Citation context analysis

Chubin, Daryl E. and Moitra, Soumyo D., "Content analysis of references: Adjunct or alternative to citation counting?" Social Studies of Science, 5, No. 4 (Nov. 1975): 423-440. File "Content analysis."

Studies the uses and limitations of citation analysis and the merits of another, more qualitative approach to evaluating the quality of research: content analysis.

Schubert, A., Zsindely, S., Telcs, A., and Braun, T., "Quantitative analysis of a visible tip of the peer review iceberg: Book reviews in chemistry," Scientometrics, 6 (Nov. 1984): 433-443. MIT Dewey Library.

Authors' abstract: "Book reviews in chemistry are practically unique in being public, 'visible' manifestations of the peer review process. Two hundred reviews of 39 books on chemical topics were subjected to statistical context analysis. Dominance of attitudes, consensus among reviewers, correlation between the reviewers' evaluations and the subsequent citation rate of the reviewed book were analysed."

Small, Henry, "Citation context analysis," in B. Dervin and M.J. Voigt, eds., Progress in Communication Sciences, Vol. III, (Norwood, N.J.: ABLEX, 1982): 287-310.

A literature review of work on citation context analysis by

researchers dissatisfied with citation counting as such, either for the purpose of information retrieval or scholarly sociology of science. Small examines the work of Moravcsik, Chubin, Cole (see Small's references, some of which are included here in secs. I and II) and others.

II. Qualitative approaches to and more general works on research evaluation

Abt Associates, "An approach to the evaluation of basic research projects," Vol. I, report to the National Science Foundation (Cambridge, Mass.: Abt, June 1967). Shelf. ABT.

> Authors' abstract: "This report describes a study of the feasibility of evaluating basic research projects. A method was developed to assist with the evaluation of completed projects in terms of their impact within the scientific community. Measures were developed to assess the impact of completed projects on scientific research areas by examining characteristics of use, patterns of diffusion, and fertility. Additional measures were proposed that could be applied to interrelated groups of projects (fields of scientific activity) that would indicate characteristics of activity, connectivity, and advancement.
>
> "A method was suggested to assist with the evaluation of basic research proposals in terms of their expected scientific impact. The proposals would be related to a structure of questions of current research interest and evaluated in terms of the degree to which these questions might be answered, the degree to which they might be changed, and the extent to which the proposal might influence the field as a whole by addressing questions of wide interest. Because both funded and unfunded proposals could be measured, the development of this method would also present the possibility of estimating scientific opportunities missed due to resources insufficient to support all meritorious proposals." (Emphasis in the original.)

Abt Associates, "A comparative study of the prospective and retrospective approaches to the evaluation of proposed basic research," report to the National Science Foundation (Cambridge, Mass.: Abt, July 1969). Shelf. ABT.

> Investigates "the possibility of developing measures that could be used in an operationally realistic way to anticipate future effectiveness of present investment alternatives in basic research." "...measures are based on changes in basic knowledge proposed by researchers seeking financial support, and the use made by subsequent investigators of knowledge gained from completed projects." An ambitious attempt to precisely specify potential and realized advances in knowledge.

Abt Associates, "A methodological approach to measuring change in science produced by basic research," report to the National Science Foundation (Cambridge, Mass.: Dec. 1968). Shelf. ABT.

> Together with the companion volumes listed immediately

above, this is an attempt to systematically evaluate and predict the impact of basic research projects. From the authors' abstract: "This study has been devoted to the development of a methodology for characterizing and measuring change in scientific knowledge produced by individual research projects. The final system which has emerged consists of three basic components: 1. A 'language' which permits the classification and description of the fundamental relations in a field of science. 2. A set of 'parameters of change' which identify the 'dimensions' in which a change in the fundamental relations can occur. 3. A mathematical formula for scaling the Range-Precision dimension of change.

"The 'language' and 'parameters of change' together form the Qualitative Theory of Scientific Change. The mathematical formulation represents the first step in developing a Quantitative Theory of Scientific Change" (emphasis added).

Abt Associates, "Methods for the strategic evaluation of research programs: The State-of-the-Art," report to the National Science Foundation (Cambridge, Mass.: 1985). Shelf.

Based primarily on a thorough literature review. Addresses both governmental (intramural and extramural) and industrial research, and attempts to answer the following questions: "1. How is evaluation generally done in the organization under consideration (viz., government or industry laboratory, funding agency)?... 2. In what ways, if any, are various evaluation techniques combined? 3. On which aspects of research outcomes do the evaluation procedures focus? 4. Under what circumstances are quantitative techniques used most often? [emphasis added] 5. What is known and thought about the effectiveness of the various techniques in use?.. 6. What kinds of available techniques have <u>not</u> been tried and why?... 7. What is known about the impact of evaluation procedures on planning and resource allocation in each type of organization or funding program? 8. What further research is needed to improve methods presently used?" In answer to question 1, the following approaches to evaluation are studied: peer judgement, socio-psychological measures, bibliometric analyses, econometric and related methods, restrospective analysis, and multidimensional methods. This report is accompanied by an annotated bibliography (see Introdution to the present bibliography).

Andrews, Frank M., ed., <u>Scientific Productivity: The Effectiveness of Research Groups in Six Countries</u> (Cambridge, England and Paris: Cambridge University Press and UNESCO, 1979). Shelf. ABT.

A report on an international study coordinated by UNESCO and performed by local researchers in each of six European countries: Austria, Belgium, Finland, Hungary, Poland, and

Sweden. The purposes of the book are to "find ways to enhance the performance effectiveness of research units and their members" and "to develop and test methods for assessing the organization and performance of research units" (p. xxix). See also review by Blume (Sec. II.).

Blume, Stuart S., "A managerial view of research," Science, 207 (January 4, 1980): 48-49. File "Measuring Output."

A largely negative review of Andrews, ed., Scientific Productivity (Sec. II). Blume's fundamental criticism is that "Most of the contributions...adopt a perspective derived in some way from organizational theory and tend to look at research groups as more or less isolated formal organizations." The sociology of science, he feels, offers more insight into the "production (and validation) of scientific knowledge."

Boggio, G. and Gallimore, R., eds., Evaluation of Research and Development: Methods for Evaluating the Results of European Community R&D Programs (Dordrecht, The Netherlands and Boston: D. Reidel, 1982). Table of contents in File "Measuring Output"; book Widener L.C. Q.180 .E9 E93 1982.

The 10 papers in this collection were presented at a conference sponsored by the Commission of the European Communities. They provide valuable insight into the content of the EC's R&D programs, but, contrary to the intent suggested by the title, do not shed much light on methods for assessing research.

Boggio, G. and Spachis-Papazois, Evaluation of Research and Development: Methodologies for R&D Evaluation in the European Community Member States, the United States of America, and Japan (Dordrecht, The Netherlands and Boston: D. Reidel, 1984). Baker Library T177 .E9 E92 1984.

Bradshaw, Gary F., et al., "Studying scientific discovery by computer simulation," Science, 222 (Dec. 2, 1983): 971-975. File "Measuring Output."

Authors' summary: "BACON is a computer program that simulates some of the important processes of scientific discovery. When provided with data about temperatures before and after two substances are brought into contact, the program infers the concept of specific heat and arrives at Black's law of temperature equilibrium. Comparison of BACON's discovery methods with historical records of Black's work casts light upon the relations between data-driven and theory-driven discovery."

Bruer, John, "The search for quality information: Schistosomiasis literature," in K.S. Warren, ed., Selectivity in Information Systems: 144-153. (See below, Sec. II.)

An attempt to develop indicators of quality of research which can be used with a computerized retrieval service, using schistosomiasis literature as an example. Bruer identifies six indicators which can be used with Index Medicus or Science Citation Index. These are all either scalar or binary. (Examples of binary indicators are 1/ published in a "highly cited journal" and 2/ "written in English").

Cetron, Marvin J. and Martino, Joseph, "The selection of R&D program content--survey of quantitative methods," IEEE Transactions on Engineering Management, EM-14, No. 1 (March 1967). File "Measuring Output." ABT.

Authors' abstract: "This paper presents a summary of methods of evaluating and selecting R&D projects. Approximately thirty methods, which have appeared in scattered places in the literature, are described briefly, and a bibliography is provided for further information. The various methods are compared and contrasted with each other relative to a standard set of characteristics relating to ease of use, and to scientific or technological area of applicablity."

Chang, K.H., "Evaluation and survey of a subfield of physics: Magnetic resonance and relaxation studies in The Netherlands," (Utrecht, The Netherlands: Stichting F.O.M., report no. FOM-37175, 1975). Shelf.

Author's abstract: "A survey of the Dutch activities...and the significant publications in the subfield [are presented]...it is concluded that the various approaches which have been followed to evaluate the impact of the particular studies, viz. interviews with experts, scanning of textbooks, searching for awards, analyzing the Science Citation Index, etc., have yielded non-contradictory results...A new procedure to analyze data obtained from the Science Citation Index is discussed in the appendix." Includes a section in the concluding chapter entitled "Evaluation: citations, a measure for quality?"

Comroe, Julius H., Jr. and Dripps, Robert D., "Scientific basis for the support of biomedical science," Science, 192 (April 9, 1976): 105-111, File "Disciplinary" ; also in H.H. Fudenberg and V.L. Melnick, eds., Biomedical Scientists and Public Policy (N.Y.: Plenum Press, 1978): 15-34. Widener L.C. R.854 U5 B53.

A summary of the authors' NIH project, immediately below. See Garfield entry, "How can we prove the value of basic research?" (Sec. II.) for discussion of Comroe and Dripps' paper.

Comroe, Julius H., Jr. and Dripps, Robert D., The Ten Top Clinical Advances in Cardio-vascular-pulmonary Medicine, 1945-1975, 2 vols., report to the National Institutes of Health, NIH 78-1522 (Washington, D.C.: Dept. of Health, Education and

Welfare, 1977).

The authors asked 100 specialists to vote on the top advances. They then identified "essential bodies of knowledge" necessary for each. Finally, they attempted to identify core published papers which advanced these areas of knowledge. They read many of these papers and classified them as basic, applied, or clinical research; development or engineering; or review papers. The authors found that basic research was fundamental to almost twice as many discoveries as all of the other categories combined, and that it should therefore be funded more generously. The project was inspired in part by dissatisfaction with Project Hindsight, a restrospective analysis of military research (see Sherwin and Isenson below, Sec. II). Compare also TRACES project, listed in Sec. II under Illinois Institute of Technology.

Cook, Thomas D. and Leviton, Laura C., "Reviewing the literature: A comparison of traditional methods with meta-analysis," Journal of Personality, 48 (Dec. 1980): 449-472. File "Measuring Output."

An investigation of the relative merits of meta-analysis ("the name given to a set of techniques for reviewing research in which the data from different studies are statistically combined") and "traditional," or qualitative, literature reviews. The authors defend the merits of the latter and point out "unique limitations" of the former. This paper provides important background for the debate over bibliometric methods in the evaluation of scientific research. See also entry under Light and Pillemer (Sec. II.).

Coward, H. Roberts and Franklin, J. Jeffrey, "Setting priorities for science-driven technology: Patents and bibliometric models," in Carole Ganz, ed., The Rise and Fall of Priority Fields, U.S. papers presented at a National Science Foundation/European Science Research Councils Symposium, Paris, France, Sept. 22-24, 1985. Shelf.

Investigates the relationship between basic research and technological innovation using co-citation maps to represent fields within the former and patent data to represent the latter. Focuses on solid state physics and concludes that "the strong pattern of interaction between the bibliometric model and patenting activity in solid state devices suggests that the technique might be used in order to identify research-driven technologies and technology-driving research areas...[This] is increasingly important for research priority setting."

Endler, Norman S., "Beyond citation counts: Developing research profiles," Canadian Psychological Review, 19 (April 1978): 152-157. File "Measuring Output."

Author's abstract: "Recent studies using...SCI publication and citation counts as indices of productivity and scholarly impact are reviewed. The advantages and limitations of this method of asessing scholarship were discussed. Finally, a more broadly based research profile was outlined." The profile weights various types of publications and addresses.

Freeman, Christopher, "Measurement of output of research and experimental development: A review paper" (Paris: UNESCO, ST/S/16 COM.69/XVI-16A, 1970). File "Measuring Output."

Review of the basic theoretical and practical problems involved with measuring research output. Includes discussions of research publications, patent statistics, and "innovations" as measures of productivity.

Fudenberg, H. Hugh, "Informing the public: Fiscal returns of biomedical research," in H.H. Fudenberg and V.L. Melnick, eds., Biomedical Scientists and Public Policy (N.Y.: Plenum Press, 1978): 35-48. Widener L.C. R.854 U5 B53.

Argues that basic research in biomedicine yields identifiable (after the fact) financial savings.

Garfield, Eugene, "How can we prove the value of basic research?" Current Contents (October 1, 1979). File "Citations."

Cites favorably and summarizes the arguments from two papers in a volume on biomedical research by Fudenberg and Melnick. One paper is by Comroe and Dripps (see entry in Sec. II.) and attempts to develop a "more objective justification for supporting basic research," particularly in biomedicine, than had previously been offered. Comroe and Dripps do so by tracing discoveries back to seminal papers and then determining whether these papers represented basic or applied research. Garfield also discusses a paper by Fudenberg (Sec. II.) which argues that basic research in biomedicine yields identifiable (after the fact) financial savings.

Gilbert, G. Nigel, "The transformation of research findings into scientific knowledge," Social Studies of Science, 6 (1976): 281-306. File "Sociology of Science." COZZENS.

The paper is concerned with "the process whereby a scientist's research findings are transformed into accredited factual knowledge...with the 'context of justification'...In contrast to the epistemological concerns of the philosophers," the author considers "only the procedures actually used by the natural scientists to decide on the validity of claims to scientific knowledge."

Giordano, Richard, "Using computers for text analysis: The development of GATOR," Center for the Social Sciences Newsletter

(Columbia University), 4, No. 2 (Spring 1985): 3-6. File "Measuring Output."

Discusses the text analysis software developed for Cole and Zuckerman's study of men and women scientists (see Sec. XI), in which they used both quantitative and qualitative (interview) data.

Griffith, Belver C., ed., Key Papers in Information Science (White Plains, N.Y.: Knowledge Industry Publications for the American Society for Information Science, 1980). Widener L.C. Z.699 .K422.

Includes papers on scientific communication (D. Crane, S. Crawford, B. Griffith), publication and citations (F. Narin, D. de Solla Price, H. Small) and other topics more directly pertinent to information retrieval and librarianship.

Goffman, William and Warren, Kenneth S., Scientific Information Systems and the Principle of Selectivity (N.Y.: Praeger, 1980). Cabot Library Z.699.5 S3 G63.

This project is motivated by a desire to better manage the medical literature, and draws upon expertise in both mathematical library science and epidemiology. (The growth of information is modelled by mathematics which is applied to the spread of disease.) Chap. 5 is entitled "Qualitative assessment of the scientific literature." The authors note here that "A complete investigation of a medical or scientific literature must involve its evaluation on a qualitative basis" and that "The best approach for qualitative selection of a literature was to obtain a consnsus of opinion of a large number of the best and most knowledgeable scientists in the field at the present time" (p. 117).

Gottfredson, S.D., et al., "Quality indicators in the scientific journal article publication process," JHU-CRSC report #29 (Baltimore: Johns Hopkins University, Center for Research in Scientific Communication, January 1977). Not held in files. No abstract available.

Griffith, B.C., Small, H.G., et al., "The structure of scientific literatures II: Toward a macro- and micro-structure for science," Science Studies, 4 (1974): 339-364. MIT Resource Sharing Center. (Not held in files; Part I under Small.)

Griliches, Zvi, "Economic problems of measuring returns on research," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 171-177. Shelf.

Focuses on patents, invention lists, and publication counts.

Griliches, Zvi, ed., R&D, Patents, and Productivity (Chicago: University of Chicago Press, 1984). See especially the following

papers: Pakes, Ariel and Griliches, Zvi, "Patents and R&D at the firm level: A first look," pp. 55-71; Griliches, Zvi, "Market value, R&D, and patents," pp. 249-258; Griliches, Zvi and Lichtenberg, Frank, "R&D and productivity growth at the industry level: Is there still a relationship?" pp. 465-501. Papers in File "Measuring Output" under Griliches. Book in Littauer HD30.42 .U5 R2 1984.

> Research on the use of patent statistics to operationalize "advances in knowledge" (p. 55) and to evaluate the effect of these advances on economic performance.

Holden, Constance, "Sociology stir at Harvard: Controversial tenure decision complicates attempts to bring in more 'quantifiers'," Science, 228 (May 10, 1985): 692-93. File "Education."

> Focuses on the case of Paul Starr, a "qualitative" sociologist refused tenure, but discusses the importance of quantification in the social sciences.

Holton, Gerald, "Can science be measured?" in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 39-68. Shelf.

> Concentrates "on some fundamental epistemological problems adhering to any attempt to make 'indicators,' no matter for what purpose," referring to Science Indicators 1972 and other publications for examples. Discusses the problems associated with generating quantitative indicators from qualitative data, and the potential for using more qualitative approaches (e.g. case studies) in evaluating the health of science.

Illinois Institute of Technology, Technology in Retrospect and Critical Events in Science ("T.R.A.C.E.S."), report to the National Science Foundation, NSF-C535 (Chicago: Illinois Institute of Technology Research Institute, 1968).

> A study of the evaluation of the quality of scientific research. The authors begin by identifying an important scientific achievement, then "trace" the events, research programs, and discoveries which were temporally and causally prior to that achievement. The authors thereby illuminate the mechanics whereby research of high quality is produced, with the hope that these mechanics can be applied in various research settings.

Irvine, John and Martin, Ben R., "Assessing basic research: The case of the Isaac Newton Telescope," Social Studies of Science, 13 (1983): 49-86. File "Martin/Irvine." (See also entries under Martin.)

> Applies the authors' method of "converging partial indicators" (see Martin & Irvine, Sec. II) "to evaluate the

scientific performance of various optical telescopes."

Irvine, John and Martin, Ben R., "Quantitative Science Policy Research," unpublished paper prepared for presentation to the Task Force on Science Policy of the House Committee on Science and Technology, October 30, 1985. Includes transcript of committee members' questions and Martin's answers. File "Martin/Irvine."

Essentially a review of M&I's research program. Q&A's provide some unusual anecdotal insight into M&I's research and into the proceedings of the committee. (See also U.S. Congress, House Committee..., Sec. II.)

Jones, P.M.S. and Willett, A.L., "Evaluation of the benefits of laboratory research and information services," Research Policy, 6 (1977): 152-163. File "Measuring Output.

The authors are part of the Programmes Analysis Unit in the British Government and have considerable experience with evaluation of laboratory research. The paper focuses on problems with evaluation associated with government research in support of industry; i.e., with ascertaining the effectivness of research in assisting industry to achieve particular objectives.

Kevles, Daniel J., "The health of science," Harpers (Aug. 1979): 26-31. File "Quality in Philosophy."

Argues that the period 1945-1970 in American science was anomalous, that American science is healthy, current declining budgets and the warnings of eminent scientists notwithstanding, and that continued emphasis on supporting the best students and researchers will keep it strong. See also Nye (Sec. VI).

Kochen, Manfred, "Models of scientific output," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 97-136. Shelf.

The paper attempts "To clarify three conceptual issues central to evaluating...information systems [to help in planning science]; To compare five models for S&T and S&T planning; To evaluate various output measures for the five models; To suggest priorities for future research in this area and for constructing new science indicators."

Küppers, Günter, Ulitzka, Norbert, and Weingart, Peter, "The awarding of the Nobel Prize: Decisions about significance in science," in C.G. Bernhard, et al., eds., Science and Society in the Time of Alfred Nobel (Oxford: Pergamon Press for the Nobel Foundation, 1982). File "Measuring Output."

"Investigates the structure and pattern of the nominating process and its interrelationship with prize decisions."

Illustrates with two cases of "revolutionary ideas" in physics: quantum theory and relativity theory. Cf. piece by Inhaber and Przednowek (Sec. I.A) which uses quantitative data in studying the prestige of Nobel winners.

Light, Richard J. and Pillemer, David B., Summing Up: The Science of Reviewing Research (Cambridge, Mass.: Harvard University Press, 1984). Shelf.

Studies literature and research reviewing. Chap. 4, "Numbers and narrative" (pp. 104-143), is an account of the relative merits of qualitative and quantitative approaches to reviewing research. See also paper by Cook and Leviton (Sec. II.).

Ling, James G. and Hand, Mary Ann, "Federal funding in materials research," Science, 209 (Sept. 12, 1980): 1203-1207. File "Measuring Output." ABT.

"The performance of 20 materials research laboratories (MRL's) at universities funded with institutional grants by...(NSF, DOE, and NASA) is evaluated in comparison with 15 other universities...receiving individually funded projects for materials research. Performance is measured by peer review and citation frequency analysis of publications, subjective evalutation of research achievements and researcher reputation by a panel of experts, review of equipment purchases and utilization, and analysis of administrative costs." Finds that productivity is roughly the same in certain respects, though significant differences exist in favor of MRL's.

Logsdon, John M., et al., "An overview of federal research evaluation activities," report prepared by the Program of Policy Studies in Science and Technology, The George Washington University, for the Division of Policy research and Analysis, NSF (April 1985). Shelf.

Main chapters are entitled: Defining research evaluation; Brief agency descriptions; Specific evaluation approaches. Covers all U.S. Government agencies which perform any significant amount of research.

Lowrance, William W., "The NAS surveys of fundamental research 1962-1974, in retrospect," Science, 197 (Sept. 23, 1977): 1254-1260. File "Measuring Output."

Discusses strengths and weaknesses of the ten disciplinary surveys sponsored by the NAS Committee on Science and Public Policy.

Martin, Ben R. and Irvine, John, "Assessing basic research: Some partial indicators of scientific progress in radio astronomy," Research Policy, 12 (1983): 61-90. File "Martin/Irvine." ABT.

An influential work in the field of research evaluation, the policy implications of which have been somewhat controversial. The paper develops a method of evaluating research "incorporating the following elements: (1) the indicators are applied to research groups rather than individual scientists; (2) the indicators based on citations are seen as reflecting the impact, rather than the quality or importance, of the research work; (3) a range of indicators are employed, each of which focusses on different aspects of a group's performance; (4) the indicators are applied to matched groups, comparing 'like' with 'like' as far as is possible; (5) because of the imperfect or partial nature of the indicators, only in those cases where they yield convergent results can it be assumed that the influence [on the indicators] of the 'other factors' [not related to the 'magnitude of the particular (scientific) contribution'] has been kept relatively small (i.e. the matching of the groups has been largely successful), and that the indicators therefore provide a reasonably reliable estimate of the contribution to scientific progress made by different research groups." (Emphasis added.)

Martin, Ben R. and Irvine, John, "CERN: Past performance and future prospects," Research Policy, 13 (1984): 183-210. File "Martin/Irvine." See also entry under Irvine and Martin.

First of a series of three papers evaluating the scientific performance of CERN. Uses the method of "converging partial indicators" (see Martin and Irvine, immediately above) to assess the "position of CERN accelerators in world high-energy physics relative to those at other large laboratories working in the field." This first paper evaluates the CERN complex as a whole, while the second focuses on individual accelerators within CERN, and the third attempts "to assess the future prospects for CERN."

Martin, Ben R. and Irvine, John, "Internal criteria for scientific choice: An evaluation of research in high-energy physics using electron accelerators," Minerva, 19 (Autumn 1981): 408-432. File "Martin/Irvine." See also entry under Irvine and Martin.

A more discursive analysis of the need for more systematic methods of research evaluation than the articles on CERN listed immediately above.

Mazlish, Bruce, "The quality of 'The quality of science': An evaluation," in La Follette, ed., Quality in Science (Cambridge, Mass.: MIT Press, 1982): 48-67. Shelf.

Suggests that science indicators are inherently value-laden; that quantitative indicators deal primarily with factors intrinsic to science and "can block other modes of understanding"; "that historical analogies...and case studies are alternate modes of understanding the quality of

science..."; that science is, in part, a political process involving choices about fundamental values; and that leadership is necessary to guide science. Science indicators are seen as "social products that must be interpreted...in a social context."

Moravcsik, Michael J., "The context of creative science," Intersciencia, 1 (July-August 1976): 71-78. File "Measuring Output."

Discusses quantitative (primarily bibliometric) and qualitative (peer review) approaches to evaluating scientific research in light of intrinsic and extrinsic "goals" of science.

Mosteller, Frederick, "Selection of papers by quality of design, analysis, and reporting," in K.S. Warren, ed., Selectivity in Information Systems: 98-116. (See below, Sec. II.)

A brief reveiw of largely qualitative criteria of quality associated with the items listed in the title.

Nalimov, V. V., Measurement of Science: Study of the Development of Science as an Information Process, translation from the Russian on microfilm (Washington, D.C.: Foreign Technology Division, U.S. Air Force Systems Command, Oct. 13, 1971).

"Measurement of Science" is alternatively translated as "scientometrics," and Nalimov is credited with inventing the term. The compiler of this bibliography has not seen the document. However, the author says of his book that "One of the chapters in the book was devoted entirely to the [Science] Citation Index. In other chapters, the Citation Index was used as the main tool for delineating the informational aspects of the evolution of science" (V.V. Nalimov, Foreword to E. Garfield, Essays of an Information Scientist, Vol. 6; see Sec. I.A.). See also E. Garfield, "In tribute to V.V. Nalimov: Renaissance scholar and scientometrician par excellence," Essays of an Information Scientist, Vol. 5 (Philadelphia: ISI Press, 1983): 417-427.

National Academy of Sciences, The Quality of Research in Science: Methods for Postperformance Evaluation in the National Science Foundation, report to the NSF by the Subcommittee on Postperformance Evaluation of Research, Committee on Science, Engineering, and Public Policy, NAS (Washington, D.C.: NAS Press, 1982). Shelf. ABT.

Discusses general problems associated with evaluating basic research, some specific techniques of evaluation (peer review, bibliometric, case studies of scientific discoveries, retrospective analysis), and a study of the research evaluation which is conducted in the Chemistry Division of the NSF. Conclusions from the study of the Chemistry Division are: "[1] Postperformance evaluation

already occurs at NSF at the project level and at the program level, at least within the...Division. [2] NSF fails to make clear to Congress the degree to which its operating procedures incorporate evaluations of past performance. [3] No additional methods of postperformance evaluation that we know of will significantly improve the selection of individual projects. [4] Additional or improved strategies of postperformance evaluation should concentrate on aggregate--for example, program--levels and on such issues as the allocation of resources among the subfields of a discipline and the support of young researchers."

Organization for Economic Cooperation and Development, The Measurement of Scientific and Technical Activities: Proposed Standard Practice for Surveys of Research and Experimental Development ("Frascati Manual 1980"), 4th ed. (Paris: OECD, 1981). Shelf.

An elaborate and comprehensive guide to the compilation and evaluation of data on R&D, intended for the use of individuals within national governments who supply such data to the OECD.

Ramachandran, G.N., "Quality in science," Current Science, 49 (Feb. 1980): 87-88. File "Measuring Output."

Brief overview of quality of science, particularly in India. Suggests that "research is of high quality if it requires considerable thinking, planning, design, and originality, on the part of the investigator, and if it has achieved the purpose for which it was started." Advocates more applied research in India.

Reingold, Nathan, review of Elkana, et al., eds., Toward a Metric of Science, Isis, 70 (1979): 443-445. File "Measuring Output."

Suggests that two models of science are implicitly discussed in Toward a Metric of Science (Sec. i). Put simplistically, one has science as part of society, the other has science as separate from, and more universal than, culture and society. For various reasons, Reingold likes Holton's and Kruskal's papers the best, though he has criticisms of each.

Robinson, Marshall (President of the Russell Sage Foundation), "Toward a better balance?" Reporting from the Russell Sage Foundation, No. 6 (May 1985). File "Measuring Output."

Essay on the relative merits of quantitative and qualitative methods in the social sciences, and how to make the latter more "reliable."

Satariano, William A., "Journal use in sociology: Citation analysis versus readership patterns," Library Quarterly, 48

(1978): 292-300. File "Measuring Output."

Author's abstract: "This paper examines the hypothesis that citation patterns parallel readership patterns in sociology." He finds that "[C]itation patterns reflect a cross-disciplinary focus that is not found in the journals most often read. Further, citation studies underestimate the usefulness of popular social science periodicals and specialty and regional journals in sociology."

Sherwin, C.W. and Isenson, R.S., First Interim Report on Project Hindsight (Washington, D.C.: Office of the Director of Defense Research and Engineering, Oct. 13, 1966 [available from NTIS]).

Traces the antecedents of important weapons. Finds that applied research is very important in the "discovery" of new weapons. Cf. Comroe and Dripps, and Illinois Institute of Technology (TRACES) in Sec. II.

Small, H.G. and Griffith, B.C., "The structure of scientific literatures I: Identifying and graphing specialties," Science Studies, 4 (1974): 17-40. MIT Resource Sharing Center. (Not held in files; Part II under Griffith.)

Smith, Richard and Fiedler, Fred E., "The measurement of scholarly work: A critical review of the literature," Educational Record, 52 (Summer 1971). File "Measuring Output."

Focuses on the strengths and weaknesses of a survey of faculty conducted by the American Council of Education in 1964 to determine the quality of academic departments. States that "Most ratings of individual faculty members are based on publications," and then goes on to elaborate.

Social Studies of Science, special "Responses and Replies" section containing critiques of Martin and Irvine's work on the evaluation of "big" basic science, 15 (1985): 525-575. File "Martin/Irvine."

Contains articles by Krige and Pestre, Moed and van Raan, Bud, Collins, and a reply by Irvine and Martin. Valuable both as a summary of M&I's work and as a comprehensive analysis of that work's limitations.

Staats, Elmer B., "The General Accounting Office: Appraising science and technology programs in the United States," Interdisciplinary Science Reviews, 3, No. 1 (1978): 7-19. File "Measuring Output."

Discusses role of GAO, including case studies of assessment of S&T.

Thackray, Arnold, "Measurement in the historiography of science," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 11-30. Shelf.

Investigates the value of quantitative methods for the history of science and for contemporary attempts to measure science.

U.S. Congress, House Committee on Science and Technology, Task Force on Science Policy, "An agenda for a study of government science policy," Dec. 1984. File "Measuring Output."

An outline of the first major review of science policy in about a decade. Includes discussions of peer review and other approaches to measuring quality in science. See also paper by La Follette under Ganz (Sec. IV).

U.S. Congress, Office of Technology Assessment, The Health of the Scientific and Technical Enterprise (Washington, D.C.: OTA, 1979). File "Measuring Output" and Shelf.

Includes short section entitled "Diagnosis of Health," which asks questions for further research for the most part.

Warren, Kenneth S., ed., Selectivity in Information Systems: Survival of the Fittest (N.Y.: Praeger, 1985). Shelf.

Focuses on bibliographic retrieval and is motivated by a concern about the burgeoning medical literature. Includes papers by the Coles, J.T. Bruer, and Mosteller. The Coles' article is essentially a reworking and summary of their NSF study. (See Sec. V.) Bruer's paper is an attempt to develop indicators which can be used with literature retrieval systems. (See Sec. II.) Mosteller focuses on standards of criteria which physicians might use in assigning priorities to the papers which they should read. (See Sec. II.) Patterson and Bailar have a very useful literature review of research on peer review. (See Sec. V.) See also Warren (Sec. II.), Goffman (Sec. I.A), and Stam (Sec. VI.). Three other papers by Larkin, Small, and Horowitz, et al., focus on various aspects of information processing and are not listed separately in this bibliography.

Warren, Kenneth S., "Selectivity within the ecosystem of scientific communication," in K.S. Warren, ed., Selectivity in Information Systems: 3-9. (See Sec II.)

Discusses the retrieval of citations from computerized information systems. Advocates "egalitarian" input of cites, but "elitist" output. That is, everything is put in, but only cites from select journals are put out until resources allow for more thorough service.

Zumeta, William, "Anatomy of the boom in postdoctoral appointments during the 1970s: Troubling implications for quality science?" Science, Technology & Human Values, 9, No. 2 (Spring 1984): 23-37. Attached is Lee Grodzins, "Commentary on Zumeta's article," Science, Technology & Human Values, 9 (Spring 1984):

38-39. File "Education."

Uses data from three national surveys to address the following questions: "What accounts for the rapid growth in the incidence of postdoctoral activity since the late 1960s? 2. Who are the 'New Postdoctorals'...and how are they different from earlier postdoctorals in terms of motivations, key demographic characteristics (i.e., sex) and, most importantly, quality? 3. To what extent has the location of postdoctoral activity shifted as its level has increased?... 4. What can be said about changes in the quality and character of postdoctoral training as its incidence has increased dramatically?" (Emphasis added.)

Ziman, John, "From parameters to portents--and back," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 268-283. Shelf.

Examines the potential for and problems with quantifying outputs of science. States that "clearly knowledge [as an output of science] is not an economic category that can be quantified. This...statement...rests upon simple fundamental principles. Any scheme for the quantification of knowledge would constitute a theoretical representation of certain processes in the real world. Within such a scheme, the logical relations between symbols standing for real operations like the creation of knowledge and its communication, aggregation and use, must be, of course, essentially equivalent to relations between the real processes they represent. Thus, the abstract algebra of the symbolic system...must be isomorphous with the intrinsic relational structure of the reality it is supposed to depict. A model that violates this principle can produce nothing but nonsense.

"Whatever it may be, the intrinsic logic of knowledge does not constitute an algebra with typical arithmetic properties..."

Compare Abt Associates report, A Methodological Approach... (Sec. II) and paper by Ganz and Sneed (Sec. VI).

III. Works Dealing Specifically with "Science Indicators"

Brooks, Harvey, "Science indicators and science policy," Scientometrics, 2, No. 5-6 (1980): 331-337. File "Science Indicators."

Discusses the definition of the research system, society's expectations of science, and the strengths and weaknesses of quantitative indicators, such as those used in Science Indicators.

Brooks, Harvey, "Science indicators and science priorities," in La Follette, ed., Quality in Science (Cambridge, Mass.: MIT Press, 1982): 1-32. Shelf.

> Views science indicators as a means to evaluate the progress of science and as a tool to set research priorities. Discusses several sets of problems with prevalent science indicators: setting the appropriate balance between factors intrinsic and extrinsic to science in specifying input and output indicators; focusing on international as well as national scientific activities; and, more broadly, relating research priorities to social and economic needs.

Cole, Stephen, et al., "Measuring the cognitive state of scientific disciplines," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 209-251. Shelf.

> From the authors' introduction: "Problems occur in interpreting the indicators presented in SI-72...Two fields appearing to be similar on a set of quantitative indicators may be qualitatively in quite different stages of development and exhibit very different cognitive structures...Clearly we need indicators of the qualitative as well as the quantitative aspects of science." However, the indicators of qualitative aspects of science used in the paper are themselves quantitative (publications and citations).

Duncan, Otis Dudley, "Science indicators and social indicators," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: John Wiley & Sons, 1978): 31-38. Shelf.

> Develops a critique of the two sets of indicators based on the view that "Science and society are of a piece" and that in evaluating their health their close interaction should be considered. (See also book by Duncan listed in Sec. VIII.A.)

Elkana, Yehuda, "Images of knowledge, qualitative indicators and science policy," in Proceedings of the First International Conference on Social Studies of Science, Nov. 4-6, 1976 (Society for Social Studies of Science, 1976). File "Science Indicators."

> "The point of this paper is that the desirable science-policy should emerge out of a critical dialogue on competing images of knowledge. The correct science-policy is neither independent of the body of knowledge, nor does it follow unambiquously from the body of knowledge. It depends on images of knowledge serving as indicators."

Evenson, R., "Technology indicators: Comments on SI78," paper presented at the third review symposium on NSB Science Indicators, May 16, 1980, Washington, D.C. File "Science Indicators."

Evenson develops an econometric approach to the measurement of research productivity.

Ezrahi, Yaron, "Political context of science indicators," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 285-327. Shelf.

A study of the interaction between values, politics, and measurement with respect to science indicators.

Garfield, Eugene, et al., "Citation data as science indicators," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: WIley, 1978): 179-207. Shelf.

Includes discussions of co-citation and bibliographic coupling, the social and cognitive structure of science, and models of scientific research.

Greenberg, Daniel S., "NSF finds science in the US alive and well," Science and Government Report, 9, No. 20 (Dec. 1, 1979). File "Measuring Output."

Journalistic summary and review of Science Indicators 1978.

Greenberg, Daniel S., "On the state of American research," Washington Report (Dec. 27, 1979): 1455-1456. File "Measuring Output."

Critical review of SI 78, summarizing arguments by GAO. (See U.S. Congress, GAO, Sec. III.)

Holmfield, John D., "Science indicators and other indicators: Some user observations," 4S (Society for Social Studies of Science) Newsletter, 3 (Fall 1978): 36-43. File "Science Indicators."

The author is on the staff of the House Committee on Science and Technology. "In this paper the focus will be on the lessons and insights that have been learned from the development and use of indicators in a number of other fields and their applicability to SI." Discusses various sorts of indicators (e.g. of water quality, housing quality).

Kitti, Carole, notes summarizing meeting on "Technology indicators: Recent developments in the use of patent data," Technology and Culture, 24 (July 1983): 473-475. File "Science Indicators."

Kochen, Manfred, "Models of scientific output," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 97-136. Shelf.

The paper attempts "To clarify three conceptual issues

central to evaluating...information systems [to help in planning science]; To compare five models for S&T and S&T planning; To evaluate various output measures for the five models; To suggest priorities for future research in this area and for constructing new science indicators."

Kruskal, William, "Taking data seriously," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 139-169. Shelf.

Argues that "documentation of...[data going into SI-72]'s modes of genesis is weak"; that "there is remarkably little study or consideration [in SI-72] of the limitations of the data used: arbitrariness or vagueness of definition, degree of random error components, errors of bias, and so on"; and "Third, there are some more technical statistical problems."

La Porte, Todd R. and Chisolm, Donald, "Indicators of the public's attitudes toward science and technology: Science Indicators: 1972, 1974 and 1976, a review and prospective reflections," paper prepared for Symposium on Science Indicators, Social Indicators Group, Social Science Research Council, May 1978. File "Science Indicators."

Critiques existing survey designs and proposes new ones.

MacAulay, James, "The ghost in the big machine: Science Indicators/1976," 4S (Society for Social Studies of Science) Newsletter, 3 (Fall 1978): 30-35. File "Science Indicators."

Critique of SI 76.

McCulloch, Rachel, "International indicators of science and technology: How does the U.S. compare," paper presented at the SSRC Review Symposium on SI-76 (May 1978). File "Science Indicators."

Criticizes SI-76 on the grounds that the relationships between inputs to and outputs from scientific research are not well enough understood to make international comparisons which have sufficient validity to guide policymakers.

McGinnis, Robert, "Science Indicators/1976: A critique," 4S (Society for Social Studies of Science) Newsletter, 3 (Fall 1978): 14-29. File "Science Indicators."

Review of SI 76 in light of Elkana, et al., eds., Toward a Metric of Science. (See Sec. i.)

Mazlish, Bruce, "The quality of 'The quality of science': An evaluation," in La Follette, ed., Quality in Science (Cambridge, Mass.: MIT Press, 1982): 48-67. Shelf.

Suggests that science indicators are inherently value-laden;

that quantitative indicators deal primarily with factors intrinsic to science and "can block other modes of understanding"; "that historical analogies...and case studies are alternate modes of understanding the quality of science..."; that science is, in part, a political process involving choices about fundamental values; and that leadership is necessary to guide science. Science indicators are seen as "social products that must be interpreted...in a social context."

Morison, Robert S., "Needs, leads, and indicators," in La Follette, ed., Quality in Science (Cambridge, Mass.: MIT Press, 1982): 33-47. Shelf.

Argues that it is easier and more fruitful to devise indicators for applied than for basic research, as it is clear "that indicators should tell us something about how science is doing in relation to what it is supposed to do for human welfare."

"NSF finds science in the US alive and well," Science and Government Report, 9 (Dec. 1, 1979): 1-5. File "Science Indicators."

Journalistic account of SI-78.

National Science Foundation, Characteristics of Recent Science/ Engineering Graduates: 1982 (Washington, D.C.: NSF, 1984). Shelf.

National Science Foundation, Manpower Resources for Scientific Activities at Universities and Colleges, January 1976 (Washington, D.C.: NSF, 1976). Shelf.

National Science Foundation, National Patterns of R&D Resources: Funds and Manpower in the United States (Washington, D.C.: NSF, 1977). Shelf.

National Science Foundation, National Patterns of Science and Technology Resources: 1984 (Washington, D.C.: NSF, 1984). Shelf.

Sections on R&D performance, R&D/GNP ration, relative funding of basic and applied research, international comparisons, and S&T personnel; statistical tables.

National Science Foundation, Science and Engineering Personnel: A National Overview (Washington, D.C.: NSF, 1985). Shelf.

See especially Chap. II, "Labor market indicators," pp. 17-22.

National Science Board, Science Indicators (Washington, D.C.: National Science Foundation, 1972, 1976, 1978, 1980, 1982, 1985). Shelf.

Organization for Economic Cooperation and Development, documents related to a Conference on Science and Technology Indicators held in Paris, Sept. 15-19, 1980. File "Science Indicators."

> Announcement of Conference; List of Papers and Schedule of "Workshop IV"; papers by Serim, Chapman and Gibbons, Johnston, Wright, Pullman; and Preliminary Report on Conference.

Price, Derek de Solla, Toward a model for science indicators," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 69-95. Shelf.

> Praises NSF's Science Indicators as a compilation of data useful to those studying science and science policy. Advocates that future attempts to develop science indicators focus on basic and applied research, rather than development, where researchers are defined operationally as those who produce published papers. Suggests procedures for evaluating the economic impact of "researchers."

U.S. Congress, General Accounting Office, Office of the Comptroller General, "Science indicators: Improvements needed in design, construction, and interpretation" (Washington, D.C.: GAO, PAD-79-35, Sept. 25, 1979). File "Science Indicators."

> A lengthy and detailed critique, primarily of SI 76. From the abstract: "They [the NSB and NSF] should emphasize a more conceptual approach which first identifies what will be measured, and then generates the appropriate data. Attempts should be made to develop indicators of the process and substance of research and to better differentiate betweeen science and technology. More interpretation of the meaning of indicators should be included in future reports."

Zeisal, Hans, "Difficulties in indicator construction: Notes and queries," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 253-258. Shelf.

> Notes on basic problems with Science Indicators and the relationship between indicators and indices.

Zuckerman, Harriet and Miller, Roberta Balstad, eds., "Science indicators: Implications for research and policy," special issue of Scientometrics, 2 (Sept., Nov. 1980 [Nos. 5-6]): 327-448. MIT Dewey Library.

> Based on a conference sponsored by the Social Science Research Council held in May 1978. Papers by H. Brooks (see this section), H. Averch, H. Zuckerman & R.B. Miller, R. McCulloch, R.B. Freeman, C.V. Kuh, J. Ben-David, R. Bowers, H.V. Riecken, and T.R. LaPorte, and shorter comments by other authors.

IV. Forecasting and Research Priorities

Abt Associates, "A comparative study of the prospective and retrospective approaches to the evaluation of proposed basic research," report to the National Science Foundation (Cambridge, Mass.: Abt, July 1969). Shelf. ABT.

Investigates "the possibility of developing measures that could be used in an operationally realistic way to anticipate future effectiveness of present investment alternatives in basic research." "...measures are based on changes in basic knowledge proposed by researchers seeking financial support, and the use made by subsequent investigators of knowledge gained from completed projects." An ambitious and probably unique attempt to precisely specify potential and realized advances in knowledge.

Ahrens, H.J., et al., "Priorities in research policy," Research Policy, 2 (1973): 94-126. File "Priorities and Foresight."

One hundred German research planners and managers were asked to "evaluate 13 research areas sponsored by the government [education, defence, health,...] according to 8 objectives [raising of the technological standard of industry, improvement of international cooperation,...]"

Brooks, Harvey, "Models for science planning," Public Administration Review, 31 (May/June 1971): 364-374. File "Priorities and Foresight."

The paper discusses "four models of the research enterprise which might serve as partial bases or rationales for planning the support and development of science...Each implies different mechanisms and criteria of choice, and the scientific system as a whole should consist of a mixture or blend of different allocation mechanisms in which the criteria appropriate to one of the four models are dominant." The four rationales are cultural, economic, social and educational. The four corresponding models are: "science as a quasi-autonomous...activity"; "science as a technical overhead"; "science as a social overhead"; and "science as a tertiary industry or consumption good." The second and fourth models are elaborated by Weinberg and Toulmin, respectively, in papers listed below in this section.

Brooks, Harvey, "The problem of research priorities," Daedalus, 107, No. 2 ("Limits of Scientific Inquiry"; Spring 1978): 171-190. Shelf.

Discusses the interrelationship between scientific and social priorities, supply of scientific talent vs. supply of funds as limits to scientific activity, and "proposal pressure" as a means to evaluate research priorities. The notion that peer review "works" with respect to the

assessment of "truth," but not utility, is widely cited in papers on the subject of peer review.

Brooks, Harvey, "Science indicators and science policy," Scientometrics, 2, No. 5-6 (1980): 331-337. File "Science Indicators."

Discusses the definition of the research system, society's expectations of science, and the strengths and weaknesses of quantitative indicators, such as those used in Science Indicators.

Brusilovsky, B. Ya., "Partial and system forecasts in scientometrics," Technological Forecasting and Social Change, 12 (August 1978): 193-200. File "Priorities and Foresight."

Author's abstract: "Science itself can be considered as a 'fuzzy system.' In attempting to deal with possible laws of scientific development we formulate a simple, partial model and illustrate its use as a means to control the strategy of investments in science." Systems analysis approach.

Carter, Sir Charles, "Conditions for the successful use of science," Science (1982).

"In some areas of intense scientific effort (in Britain), commercial priorities tend to be forgotten...Evidence suggests that the successful use of science depends on the overall quality of management rather than specifically on its degree of scientific knowledge."

Carter, Luther J., "More stress on applied science at NSF," Science, 205 (August 17, 1979): 675-676. File "Priorities and Foresight."

Journalistic account of changes under the Carter Administration.

Chynoweth, A.G., "Science-engineering coupling and some priorities in materials research," Annual Review of Materials Science, 5 (1975): 27-42. File "Priorities and Foresight."

Suggests that social needs should guide priority-setting in materials science, and discusses the implications of this proposition in some detail.

Coward, H. Roberts and Franklin, J. Jeffrey, "Setting priorities for science-driven technology: Patents and bibliometric models," in Carole Ganz, ed., The Rise and Fall of Priority Fields, U.S. papers presented at a National Science Foundation/European Science Research Councils Symposium, Paris, France, Sept. 22-24, 1985. Shelf.

Investigates the relationship between basic research and technological innovation using co-citation maps to represent

fields within the former and patent data to represent the latter. Focuses on solid state physics and concludes that "the strong pattern of interaction between the bibliometric model and patenting activity in solid state devices suggests that the technique might be used in order to identify research-driven technologies and technology-driving research areas...[This] is increasingly important for research priority setting."

Ganz, Carole, ed., The Rise and Fall of Priority Fields, U.S. papers presented at a National Science Foundation/European Science Research Councils Symposium, Paris, France, Sept. 22-24, 1985. Shelf.

Bodo Bartocha, head of NSF's Division of International Programs, gives a historical overview; Coward and Franklin of the Center for Research Planning investigate the integration of patent and bibliometric statistics to better understand the science-technology interface (see immediately above); Ganz and Sneed offer an application of concepts from the philosophy of science to problems of setting priorities, with a valuable bibliography (see Sec. VI); La Follette discusses the ongoing study of U.S. science policy by the House Committee on Science snd Technology. There are also papers by Ratchford, Mayfield, Ryer, and Willenbrock.

Garfield, Eugene, "The economic impact of research and development," Current Contents (Dec. 21, 1981): 5-15. File "Priorities and Forecasting."

Includes data on the economic return of basic research and summaries of Edwin Mansfield's work. Has a useful bibliography.

Hoaglin, David C., et al., Data for Decisions (Cambridge, Mass.: Abt Associates, 1982). Shelf.

Investigation of methods for gathering data to be used in formulating public policy. Includes a "quality checklist" for each method.

Irvine, John and Martin, Ben R., Foresight in Science: Picking the Winners (London: Frances Pinter, 1984). Shelf. ABT.

Study of research forecasting. Includes cross-national comparisons (U.K., France, West Germany, U.S., Japan). U.S. section covers COSPUP field surveys and NSF commissioned studies. Addresses both basic and "strategic" research.

Krauch, Helmut, "Priorities for research and technological development," Research Policy, 1 (1971/72): 28-39. File "Priorities and Foresight."

Results of a public opinion poll on research priorities in West Germany are compared with government expenditures. The

priorities, determined from the two sources, diverge significantly. It is concluded that interest groups have too much influence.

Lederman, Leonard L., "Foresight activities in the U.S.A.: Time for a re-assessment?" Long Range Planning, 17, No. 3 (1984): 41-50. File "Priorities and Foresight."

Does not focus on forecasting the results of scientific research, but is nonetheless of some value as a generic summary, especially because the author was with the NSF when he wrote the piece.

Leeper, Pepper, "Which disease? What vaccines? How to set priorities," News Report (of the National Academy of Sciences), 35 (Dec. 1984-Jan. 1985): 4-11. File "Disciplinary."

Discusses priority-setting in research on public health.

Lepkowski, Will, "Public concern: New force in science policy," Chemical & Engineering News (March 29, 1982): 43-44. File "Priorities and Foresight."

"Social context and public disenchantment with science and technology must be considered in making science policy, recent reports say." Discusses OECD report by H. Brooks and contrasts it favorably with statements by George Keyworth.

Library of Congress, Congressional Research Service, Science Policy Division, "An overview of the decision making process in the areas of research and development priorities," prepared for the Office of Technology Assessment Technology Assessment Advisory Council, May 26, 1976. File "Priorities and Foresight."

Includes sections entitled "The peer review system" and "Methodology for evaluating the economic and social impacts of R and D expenditures."

Maddox, John, "Choice and the scientific community," in Shils, ed., Criteria for Scientific Development (Cambridge, Mass.: MIT Press, 1968): 44-62. Shelf.

Contrasts choice of research topic and of the applications of findings. Concludes that "the wisdom of the choices which need to be made both in academic science and in its application will be determined by the intellectual cohesion of the scientific community as such."

Martin, Ben R. and Irvine, John, "Internal criteria for scientific choice: An evaluation of research in high-energy physics using electron accelerators," Minerva, 19 (Autumn 1981): 408-432. File "Martin/Irvine." See also entry under Irvine.

A discursive analysis of the need for more systematic methods of research evaluation at CERN and other facilities.

Public Agenda Foundation, Science Policy Priorities and the Public: A Report on a Pilot Project to Assess Public Attitudes About Priorities and Indicators of Quality for Scientific Research (Prepared for the project "Assessment of science: Development and testing of indicators of quality," Harvard University, 1980). Shelf.

Authors' preface: "This report summarizes the findings of a pilot study on public attitudes toward a range of controversial issues relating, in general, to science and technology and quality of life. Specifically, the Public Agenda assembled small groups of citizens to probe their reactions to a variety of scientific research proposals. The goal of the pilot study, as described in the proposal, was to generate hypotheses about implicit and explicit criteria people use to assess the impact of science and technology on the quality of life.

"The project was designed to explore the following questions: 1. Can the public make a contribution to the development of quality indicators?...2. What criteria do average citizens use to assess research piorities?...3. Do average citizens approach science as scientists do?...4. Are there measurable differences between superficial public opinion and considered public judgement?"

A number of hypotheses are then proposed, based on the research.

Ross, H.H., et al., "Setting research priorities," Research Policy, 8 (1979): 260-272. File "Priorities and Foresight."

Authors' abstract: "An algorithm, specially developed to set research priorities, was used..to rank ten different projects...previously ranked...by personal judgement. Comparison of the results from both methods indicates excellent agreement among rankers within each method, little discrepancy between the two methods in final rankings, and no apparent advantage to the use of the algorithm."

Snellen, I. Th. M., "Social merit as a criterion of scientific choice: Its application in Dutch science policy," Minerva, 21 (Spring 1983): 16-36. File "Priorities and Foresight."

Uses a method for assigning weights to social goals involving "the comparison of pairs of alternative programmes." Acknowledges Weinberg's early work in the field (see below, this section). Includes a very good discussion of science policy-making in the Netherlands.

Thomas, Lewis, "On the planning of science," in H.H. Fudenberg and V.L. Melnick, eds., Biomedical Scientists and Public Policy (N.Y.: Plenum Press): 67-76. Widener R.854 U5 B53.

Toulmin, Stephen, "The complexity of scientific choice: A stocktaking," in Shils, ed., Criteria for Scientific Development (Cambridge, Mass.: MIT Press, 1968): 63-79. Shelf.

Reviews and extends the arguments presented by Polanyi, Weinberg, Carter, and Maddox on the subject of scientific choice. (All of these articles are reprinted in the MIT Press volume; Weinberg's and Maddox' are listed in this section of the current bibliography.) Suggests in conclusion that the research contract system, whereby private institutes such as Rand conduct the government's research, successfully combine scientific expertise, administrative flexibility, and financial responsibility, and should be tried in Britain (from where Toulmin writes).

Toulmin, Stephen, "The complexity of scientific choice II: Culture, overheads or tertiary industry?" in Shils, ed., Criteria for Scientific Development (Cambridge, Mass.: MIT Press, 1986): 119-133. Shelf.

Discusses two justifications for funding basic research: basic research as an overhead (see Weinberg below, this section) and basic research as high culture. Proposes as an alternative the concept of basic research as a tertiary industry, which will maintain employment after primary and secondary industries are in decline. Also discusses problems with quantification and evaluation of the economic (employment) effects of research.

United Nations Educational, Scientific and Cultural Organization, Method for Priority Determination in Science and Technology: UNESCO/UNACAST Surveys of Institutional Needs of developing Countries in the field of Science and Technology (Paris: UNESCO, 1978). Shelf.

"The disclosure of [areas of priority] is effected through an assessment of the relevance of scientific and technological disciplines for national development objectives and programmes. The assessment is made by panels of experts drawn from governmental departments and from scientific institutions...The output of the method is a series of priority charts and profiles showing the relative merits of fields of science and technology for the achievement of development objectives, and the relative dependence of the latter on the former."

United Nations Educational, Scientific and Cultural Organization, "Seminar on evaluation of research priority determination methods in science and technology (Paris, 27-30 September 1983): Final report," (SC-83/CONF.731/3, Sept. 30, 1983). File "Priorities and Foresight."

Summarizes the results of a planning exercise using the method. (See immediately above.)

United Nations Educational, Scientific and Cultural Organization, The UNESCO Method for Priority Determination in Science and Technology (Paris: UNESCO, 1981??). Excerpts on Shelf.

> National case studies of the application of the UNESCO method for priority determination: Argentina, Australia, Costa Rica, Jordan, Nepal, Peru, Portugal. (See above, under UNESCO in this section, for description of the method.)

U.S. Congress, Committee on Science and Astronautics, report by the National Academy of Sciences, Basic Research and National Goals (Washington, D.C.: USGPO, March 1965). File "Priorities and Foresight."

> The report includes papers by several scientists and science policy experts. Only the summary of the report is in the file.

Warsh, David, "New index shows high-technology jobs on the decline," Boston Globe (August 7, 1979). File "Priorities and Foresight."

> Disucsses forecast by Derek de Solla Price using a "high-technology recruitment index," based on help-wanted advertising in 40 periodicals and newspapers.

Weinberg, Alvin M., "Criteria for scientific choice," in Shils, ed., Criteria for Scientific Development (Cambridge, Mass.: MIT Press, 1968): 21-33. Shelf.

> Distinguishes "internal" from "external" criteria. The former are 1/ "Is the field ready for exploitation?" and 2/ "Are the scientists in the field really competent?" Weinberg observes that only experts active in the field can answer these questions. External criteria are technological merit, scientific merit (i.e. whether research in one field fertilizes other fields), and social merit. The author concludes "that the most valid criteria for assesing scientific fields [which are to be publicly funded] come from without rather than from within the scientific discipline that is being rated."

Weinberg, Alvin, "Criteria for scientific choice II: The two cultures," in Shils, ed., Criteria for Scientific Development (Cambridge, Mass.: MIT Press, 1968): 80-91. Shelf.

> Develops the idea of funding for basic research as an overhead in relation to the whole scientific and technological enterprise. The absolute amount of funding is determined accordingly, through the political process.

Weinberg, Alvin M., "Values in science: Unity as a criterion of scientific choice," Minerva, 22 (Spring 1984): 1-12. File "Priorities and Foresight."

"Truth" is posited as the underlying value of scientific practice, "unity" as that of scientific adminsistration, where "administration" means "the art of choosing, among infinitely many possible questions answerable by science, which questions to ask." The criterion of "unity" "stems directly from a belief that a unified body of scientific knowledge, in which the different parts of science are related to each other, are more consistent with each other, and illuminate each other, is in a very fundamental sense better--a greater intellectual achievemnt, more powerful, more beautiful--than an aggregate of scientific knowledge not so unified."

Yankelovich, Daniel and Lefkowitz, Bernard, "The public debate on growth: Preparing for resolution," Technological Forecasting and Social Change, 17 (1980): 95-140. File "Priorities and Foresight."

"This report consists of three parts. The First...presents our summary interpretation of a wide body of social research data showing the attitudes, beliefs, and values Americans currently hold on the subject of economic growth...The research reveals a picture of Americans midway between...unfettered optimism...and a growing psychology of limits. The second part...considers how this ambivalent state of mind might resolve itself in the future...we have included a tabular presentation of survey data as a reference source for analysts...

V. Peer Review

Anderson, Richard C., et al., "Publication ratings versus peer ratings of universities," Journal of the American Society for Information Science (March 1978): 91-103. File "Measuring Output."

"Presents a quantitative comparison of peer versus bibliometric procedures...The peer ratings used are the Roose-Anderson rating of the quality of graduate faculty in 10 scientific fields." Bibliometric ratings are based on numbers of papers and citations.

Cole, Jonathan R. and Cole, Stephen, "Chance and consensus in peer review," Science, 214 (Nov. 20, 1981): 881-886. File "Peer Review."

Author's summary: "An experiment in which 150 proposals submitted to the National Science Foundation were evaluated independently by a new set of reviewers indicates that getting a research grant depends to a significant extent on chance. The degree of disagreement within the population of

eligible reviewers indicates that whether or not a proposal is funded depends in a large proportion of cases upon which reviewers happen to be selected for it. No systematic bias in the selection of NSF reviewers was found." Based on the Coles' study of the NSF peer-review system (see below). See also critique by Harnad, listed in this section.

Cole, Jonathan R. and Cole, Stephen, "Experts' 'consensus' and decision-making at the National Science Foundation," in K.S. Warren, Selectivity in Information Systems: 27-63. (Shelf; see Sec. II.).

Largely a reworking of the Coles' article in Science, "Chance and consensus in peer review." (See immediately above.) Both articles are based on the Coles larger study of peer review in the NSF (immediately below). The conclusion presents some new views on consensus and lack thereof in the process of peer review.

Cole, Stephen, Rubin, Leonard, and Cole, Jonathan R., Peer Review in the National Science Foundation: Phase One of a Study; Cole, Cole, and NAS Committee on Science and Public Policy, Peer Review in the National Science Foundation: Phase Two of a Study (Washington, D.C.: National Academy of Sciences, 1978, 1981). Phase One on Shelf.

The authors analyze 1,200 NSF proposals and make five major conclusions (quotes from p. 29 of Coles' paper in Warren, ed., listed immediately above): "1. There is a high correlation between reviewer ratings and grants made... 2. ...there was not a high correlation between grants awarded and measures of the previous scientific performance of the applicants... 3. Reviewers at major institutions did not treat proposals from applicants at major institutions more favorably than did reviewers from lesser institutions... 4. Professional age (length of career) had no strong effect either on ratings received or on the probability of receiving a grant. 5. There were low or moderate correlations between reviewer ratings (and the funding decision) and the following characteristics of the applicants: prestige rank of current academic department, academic rank, geographic location, NSF funding history over the previous five years, and locus of Ph.D. training."

"Congressmen Conlan and Bauman attack NSF peer review," Physics Today, 28 (Sept. 1975): 77-78, 80. File "Peer Review."

Journalistic account of one of the periodic Congressional attacks on the NSF. Congressmen ask, Who reviews the (possibly biased) reviewers?

Gustafson, Thane, "The controversy over peer review," Science, 190 (December 12, 1975): 1060-1066. File "Peer Review."

Cogently defends peer review against a number of critics

while suggesting some modifications in the system(s).

Harnard, Steven, ed., "Peer commentary on peer review: A case study in scientific quality control," The Behavioral and Brain sciences, 5, No. 2 (Cambridge, England: Cambridge University Press, 1982). File "Peer Review."

This document includes about 50 short commentaries on the effectiveness of peer review in determining the quality of research. The articles focus on a controversial study by Peters and Ceci in which previously rejected papers were resubmitted to the same journals under fictitious authors' names. Many of these resubmitted papers were accepted.

Harnad, Steven, "Rational disagreement in peer review," Science, Technology, & Human Values, special issue entitled "Peer review and public policy," 10, No. 3 (Summer 1985): 55-62. Shelf.

Critiques the Coles' paper, "Chance and consensus in peer review" (see above), using statistical arguments and the guiding notion that "a certain degree of disagreement is not only a healthy but an informative and even essential aspect of scientific activity and that it should be clearly represented as such, rather than as some capricious and arbitrary shortcoming of scientific judgement, responsible only for unfairness and waste" (p. 59).

Hilts, Philip J., "Low-ranked social science projects moved to top," Washington Post (October 2, 1983): A2. File "Peer Review."

A possible case of overt political intrusion into the peer review process; illustrates the relative vagueness of the criteria by which social science research is assessed.

Patterson, Kay and Bailar, John C. III, "A review of journal peer review," in K.S. Warren, ed., Selectivity in Information Systems: 64-82. (See Sec. II.)

A valuable review of the literature.

Ravetz, J.R., Scientific Knowledge and Its Social Problems (Oxford: Clarendon Press of Oxford University Press, 1971), Chap. 10, "Quality control in science." File "Measuring Output." Book in Cabot Library Q.175 .R3.

Argues for qualitative (peer review) approach to evaluating scientific research, though does not explicitly employ the terms "qualitative" and "quantitative." The author observes that "It is impossible to design a simple set of routine tests, by which one could assign some numerical marks to a scientific problem, and then grade it on a linear scale. Nor indeed would it be feasible to erect a formal system of categories of quality, and train up a corps of expert assessors...to operate in their framework. For the

techniques are so subtle, the appropriate criteria of adequacy and value so specialized, and the materials so rapidly changing, that any fixed and formalized categories would be a blunt and obsolete instrument as soon as it were brought into use. The result of this special characteristic of science is that if there are to be truly expert assessments of quality of work, they must be made by a section of those who are actually engaged upon that work."

Roy, Rustum, "Peer review" (letter to the editor), Physics Today, 29 (July 1976). File "Peer Review."

Addresses possible abuses of peer review system investigated by the Symington subcommittee in 1975.

Science, Technology, & Human Values, 10, No. 3 (Summer 1985), special issue entitled "Peer review and public policy," guest co-editors Daryl Chubin and Sheila Jasanoff. Shelf.

The first article, by Clark and Majone, is a theoretical investigation of "The critical appraisal of scientific inquiries with policy implications," but hardly discusses peer review. Jasanoff's piece is the most appropriate to the volume's topic. It studies peer review of research in a regulatory context. There are shorter papers by Porter and Rossini; Gillespie, Chubin, and Kurzon; Harnad (see above in this section); Kalberer, Roy, Ritvo, and Stossel.

VI. Quality and Quantity in History of Science and Philosophy

Baldwin, James Mark, ed., Dictionary of Philosophy and Psychology, Vol. 2 (N.Y.: Macmillan, 1902), article on "Quality," pp. 406-409. File "Quality in Philosophy."

Bealer, George, Quality and Concept (Oxford: Clarendon Press of Oxford University Press, 1982). Wid. L.C. B945 .B3743 Q34 1982.

Bealer develops a theory of "properties, relations, and propositions" which attempts to "unify a great many topics central to logic, metaphysics, psychology, and theory of language."

Böhme, Gernot, Alternativen der Wissenschaft (Frankfurt am Main: Suhrkamp, 1980). Shelf.

See especially Chap. III, "Antike Alternativen," which discusses Plato and Aristotle.

Boring, Edwin G., "The beginning and growth of measurement in psychology," in Woolf, ed. (Sec. VI).

Brunschvicg, Léon, Les Étapes de la Philosophie Mathématique (Paris: Librairies Félix Alcan, 1912), especially Chap. 4, "Le mathématisme des platoniciens", pp. 43-69. Chapter 4 in file "Quality in Philosophy." Book in Widener Math 66.6.

> This chapter is cited by Koyré in Metaphysics and Measurement (Sec. VI) in support of his claim that Plato represented two traditions of mathematics: one proto-scientific, the other quasi-mystical.

Brunschvicg, Léon, Le Rôle du Pythagorisme dans l'Évolution des Idées (Paris: Hermann & Cie., 1937). Widener Phil 1182.10.

Burtt, Edwin Arthur, The Metaphysical Foundations of Modern Science (Garden City, N.J.: Doubleday Anchor Books, 1954). Shelf.

> A treatise on quantity, quality, and mathematics in modern science.

Clark, Joseph T., "The philosophy of science and the history of science," in M. Clagett, ed., Critical Problems in the History of Science (Madison, Wisc.: University of Wisconsin Press, 1959): 103-140. File "Quality in Philosophy."

> Starts from the thesis that the history of science can be usefully studied using the analytic structure of science, as opposed to "cumulative" historical methods per se. Among the topics Clark investigates is Oresme's role in the mathematization of physics.

Crombie, A.C., "Quantification in medieval physics," in Woolf, ed. (Sec. VI).

Deutsch, Karl W., et al., "Conditions favoring major advances in the social sciences," Science, 171 (Feb. 5, 1971): 450-459. File "Quality in Philosophy."

> A detailed investigation into the "environmental group conditions for creative success in the social sciences," with 62 examples drawn from the history of various social science fields.

Edge, David, "Quantitative measures of communication in science: A critical review," History of Science, 17 (1979): 102-134. File "Quality in Philosophy."

> A detailed study of those quantitative methods which might be useful in historical studies of scientific communication. Among the quantitative measures discussed are citation, co-citation, "trusted assessorship" (personal acknowledgements in papers), co-authorship, teacher-student relationships, and "other public traces of informal communication." Edge is, on the whole, critical of quantitative methods in the history of science, but does conclude that they may be useful as "secondary validation"

for qualitative research.

Fox, Karl A., Social Indicators and Social Theory: Elements of an Operational System (N.Y.: John Wiley & Sons, 1974): Chaps. 1 and 2. File "Quality in Philosophy." Book in Gutman Education Library H61 .F62.

Reviews the history (particularly the intellectual history) of the "social indicators movement." Excellent social theoretical background.

Ganz, Carole and Sneed, Joseph D., "Setting priorities: Intellectual structure of a discipline," in Carole Ganz, ed., The Rise and Fall of Priority Fields, U.S. papers presented as a National Science Foundation/European Science Research Councils Symposium, Paris, France, Sept. 22-24, 1985. Shelf.

Sneed is a philosopher of science at the Colorado School of Mines who is a principal originator of the "structuralist" view of scientific activity, in which the "most important products [of that activity] are the mathematical-conceptual structures that are used to make...[empirical] statements...A single scientific community is identified by its commitment to use a specific conceptual structure to deal with a specific range of phenomena" (p. 5). Ganz is a philosopher of science working in the Division of International Programs at the NSF. The authors develop a specific form of content analysis, based on Sneed's and Kuhn's work, compare the results of the application of this technique with cluster maps in co-citation analysis, and ask if this approach can "aid in early recognition of scientific specialties leading to technologies with social and economic value" and "provide some insight into what guides choice of research problems and how this choice might be influenced." See other, non-annotated, entries under Sneed in this section.

Gerard, R.W., "Quantification in biology," in Woolf, ed. (Sec. VI).

Guerlac, Henry, "Quantification in chemistry," in Woolf, ed. (Sec. VI).

Hahn, Roger, A Bibliography of Quantitative Studies on Science and its History (Berkeley, Calif.: University of California at Berkeley, Berkeley Papers in History of Science, No. 3, 1980). Shelf.

Holton, Gerald, "Do scientists need a philosophy?" Times (of London) Literary Supplement (November 2, 1984): 1231. File "Holton Papers."

Suggests that the "analysis of current dimensions of scientific innovation" should begin to draw more upon ethics than it has in the past, given the fundamental moral

problems with which science is involved in the contemporary world.

Kevles, Daniel J., "The health of science," Harpers (Aug. 1979): 26-31. File "Quality in Philosophy."

Argues that the period 1945-1970 in American science was anomalous, that American science is healthy, current declining budgets and the warnings of eminent scientists notwithstanding, and that continued emphasis on supporting the best students and researchers will keep it strong. See also Nye, and Paul (Sec. VI).

Koyré, Alexandre, Metaphysics and Measurement (Cambridge, Mass.: Harvard University Press, 1968). Shelf.

A central work in the field, and relevant to any study of the philosophical foundations of science indicators. See especially Chaps. 1 and 2: "Galileo and the scientific revolution of the seventeenth century" (pp. 1-15) and "Galileo and Plato" (pp. 16-43).

Kuhn, Thomas S., "The function of measurement in modern physical science," in Woolf, ed. (Sec. VI).

Kyburg, Henry E., Jr., Philosophy of Science: A Formal Approach (N.Y.: Macmillan, 1968), Chap. 3, "Quantities," pp. 55-86. Shelf.

Although a "formal approach," Kyburg recognizes a continuum of quantitization of measurement among the different sciences. "Sciences that employ...(fully quantitative judgements) are no doubt more powerful and more useful (they provide quantitative predictions) than sciences that do not; but we should not regard them as different in basic characteristics" (p. 85).

Lasswell, Harold D., "The qualitative and quantitative in political and legal analysis," in Lerner, ed. (Sec. VI).

Lazarsfeld, Paul F., "Notes on the history of quantification in sociology--trends, sources, problems," in Woolf, ed. (Sec. VI).

Leontief, Wassily, "The problem of quality and quantity in economics," in Lerner, ed. (Sec. VI).

Lerner, Daniel, "Introduction, on quantity and quality," in Lerner, ed. (Sec. VI).

A historical account of the topic and an introduction to the papers in the volume.

Lerner, Daniel, ed., Quantity and Quality: The Hayden Colloquium on Scientific Method and Concept (N.Y.: Free Press of Glencoe, 1961). Widener S 308.36.

See Lerner, Weisskopf, Stevens, Rosenblith, Lasswell, Leontief, and Spengler in Sec. VI, and Kemeny in Sec. VIII.

Morman, Edward T., "Citation analysis and the current debate over quantitative methods in the social studies of science," 4S (Society for Social Studies of Science) Newsletter, 5 (Summer 1980): 7-13. File "Citations."

Intellectual history of the debate over the appropriateness of citation and co-citation analysis in the history of science. Focusses on Price, Garfield, and the Coles on the one hand, and Edge on the other (though other authors are discussed). Useful set of references.

Mulkay, Michael, "Applied philosophy and philosophers' practice," Science, Technology, & Human Values, 6 (Winter 1981): 7-15.

Critiques papers in the previous issue of STHV, which was partly on applied philosophy of science. (See paper by Shrader-Frechette in Sec. VI.) The author is a sociologist and his theme, put simplistically, is that both scientists and philosophers practice within social groups, that their practice differs, and that these differing practices affect epistemological or analytical approaches. In order to "influence others' actions," applied philosophers "might have to engage actively in the social life of their subjects [scientists]...instead of relying almost exclusively on analysis of the general structure of scientsts' intellectual accomplishments."

Myerson, Emile, Identity and Reality, trans. Kate Loewenberg (N.Y.: Dover Publications, 1962). Shelf.

Of most immediate interest is Chap. 10, "Non-mechanical theories," pp. 323-353, an account of the evolution of "Aristotelian science."

Naydler, Jeremy, "The poverty of Popperism," The Thomist, 46 (Jan. 1982): 92-107.

A critique of one variant of logical positivism from the point of view of a neo-(medieval) realist.

Naydler, Jeremy, "The regeneration of realism and the recovery of a science of qualities," International Philosophical Quarterly, 23 (June 1983): 155-172. File "Quality in Philosophy."

An account of Medieval realism, its Aristotelian and Platonic roots, and its supposed degeneration into "nominalist" modern science.

Nye, Mary Jo, "Scientific decline: Is quantitative evaluation enough?" Isis, 75 (1984): 697-708. File "Quality in Philosophy."

A study of nineteenth century attempts to quantify the supposed decline of French science. Draws parallels with the current situation in the US. Considerable relevance to the modern science indicators movement. See also Kevles, and Paul (Sec. VI).

Paul, Henry W., The Sorcerer's Apprentice: The French Scientist's Image of German Science: 1840-1919 (Gainesville, Fla.: University of Florida Social Sciences Monograph No. 44, 1972). Shelf.

A case study illustrating the semi-subjective nature of the evaluation of the quality of scientific research. See also Nye, and Kevles (this Sec.).

Ravetz, Jerome R., Scientific Knowledge and Its Social Problems (Oxford: The Clarendon Press of Oxford University Press, 1971), Chap. 10, "Quality control in science." File "Measuring Output." Book at Cabot Q175 .R3.

Argues strongly for qualitative approach to evaluating scientific research, though does not explicitly employ the terms "qualitative" and "quantitative." The author observes that "It is impossible to design a simple set of routine tests, by which one could assign some numerical marks to a scientific problem, and then grade it on a linear scale. Nor indeed would it be feasible to erect a formal system of categories of quality, and train up a corps of expert assessors...to operate in their framework. For the techniques are so subtle, the appropriate criteria of adequacy and value so specialized, and the materials so rapidly changing, that any fixed and formalized categories would be a blunt and obsolete instrument as soon as it were brought into use. The result of this special characteristic of science is that if there are to be truly expert assessments of quality of work, they must be made by a section of those who are actually engaged upon that work."

Rescher, Nicholas, Scientific Progress: A Philosophical Essay on the Economics of Research in Natural Science (Pittsburgh, Penn.: University of Pittsburgh Press, 1979). Cabot Q 180.55 .E25 R47 1978b.

See also a largely positive review by Philip Morrison in Scientific American, 240 (May 1979): 37-40. (File "Quality in Philosophy" under Rescher.) Morrison describes the book as follows: "The philosopher-analyst author has sought to quantify the almost indefinable and to project its future from a few empirical results and a boxful of argument, based on a sweep of thought from...Leibniz,...Peirce,...and Reymond to ...Feynman and...[D. de S.] Price."

Roger, Jacques, "Science, nature, quality," Diogenes, No. 88 (Winter 1974): 69-76. File "Quality in Philosophy."

A review of the philosophic bases of Aristotelian and modern

physics, with particular reference to quality and quantity.

Rosenblith, Walter A., "The quantification of the electrical activity of the nervous system," in Lerner, ed. (Sec. VI).

Schware, Robert, Quantification in the History of Political Thought: Toward a Qualitative Approach (Westport, Conn: Greenwood Press, 1981). Widener L.C. JA.81 S347.

An examination of quality and quantity in the political thought of philosophers from Plato to Weber. Separate chapters on Bacon, Hobbes, and Mill.

Shrader-Frechette, Kristin S., "Technology assessment as applied philosophy of science," Science, Technology, & Human Values, 6 (Fall 1980): 33-50.

The author elaborates upon the following statement: "A philosopher of science can contribute to technology assessment and hence ultimately to the guidance of technology-related public policy on at least two levels: that of conceptual and methodological analysis, and that of concrete applications, where the concepts and methods are employed in specific contexts."

Shryock, Richard H., "The history of quantification in medical science," in Woolf, ed. (Sec. VI).

Sneed, Joseph D., "Philosophical problems in the empirical science of science: A formal approach," Erkenntnis, 10 (1976): 115-146. File "Quality in Philosophy."

See Ganz and Sneed in this section.

Sneed, Joseph D., The Logical Structure of Mathematical Physics, 2nd ed. (Dordrecht, The Netherlands and Boston: Reidel, 1979). MIT Science Library QC20 .S671 1979.

See Ganz and Sneed in this section.

Spengler, Joseph J., "On the progress of quantification in economics," in Woolf, ed. (Sec. VI).

Spengler, Joseph J., "Quantification in economics: Its history," in Lerner, ed. (Sec. VI).

Stam, David H., "Concluding unscientific postscript: Reflections on selectivity from a nontechnical perspective," in K.S. Warren, ed., Selectivity in Information Systems: 166-170. (See Sec. II.)

A short think-piece on selecting high-quality literature. The author is director of the New York Public Library's research division.

Stevens, S.S., "The quantification of sensation," in Lerner, ed. (Sec. VI).

Weisskopf, Victor F., "Quality and quantity in quantum physics," in Lerner, ed. (Sec. VI).

Wilks, S.S., "Some aspects of quantification in science," in Woolf, ed. (Sec VI).

Review of quantification and measurement in the history and philosophy of science.

Woolf, Harry, ed., Quantification: A History of the Meaning of Measurement in the Natural and Social Sciences (Indianapolis, Ind.: Bobbs-Merrill, 1961. Widener S 840.95.

Papers read at a conference held at the offices of the Social Science Research Council Nov. 20-21, 1959. The conference was affiliated with the Joint SSRC-NRC Committee on the History of Science. See Wilks, Crombie, Gerard, Boring, Lazardsfeld Kuhn, Guerlac, Shryock, and Spengler, in Sec. VI. for titles of papers.

Zandvoort, Henk, "An extension of Sneed's reconstruction of classical particle mechanics to complex applications, and an alternative approach to special force laws," Erkenntnis, 18 (1982): 39-63. File "Quality in Philosophy."

See Ganz and Sneed above, in this section.

Zandvoort, Henk, "Comments on the notion 'Empirical claim of a specialization theory net' within the structuralist conception of theories," Erkenntnis, 18 (1982): 25-38. File "Quality in Philosophy."

See Ganz and Sneed above, this section.

Zuckerman, Harriet, "Theory choice and problem choice in science," Sociological Inquiry, 48 (1978): 65-95. File "Sociology of Science."

Reviews "current sociological and philosophical work bearing on cognitive change [in science]." Finds that scientists' behavior corresponds but little to "epistemological prescriptions of how they should behave," but "corresponds more than one might suppose to often stated methodological precepts which give primacy to assessed significance and feasibility of solution."

VII. Education

Bayer, Alan E. and Folger, John, "Some correlates of a citation measure of productivity in science," Sociology of Education, 39 (1966): 381-390. File "Citations." COZZENS.

Authors' abstract: "The Science Citation Index provides an easy way to derive criterion measures of scientific accomplishment. Measures derived from citation counts, the principle criterion, have high face validity. These criterion measures are found to have a low but positive correlation with the quality of scientists' graduate education [based on Cartter report] and no relation to his measured I.Q. score."

Beyer, Janice M., and Snipper, Reuben, "Objective versus subjective indicators of quality in graduate education," Sociology of Education, 47 (Fall 1974): 541-557. File "Education."

Investigates the difficulty with which the same quantitative measures are applied across different scientific disciplines. Uses "both original data and data from published sources" to examine "the relationship of the rated quality [in the Cartter report] of university departments to other possible quality indicators in two physical and two social sciences." The original data is based on questionnaires sent to faculty members, which ask them to name scholars whom they would like to hire for their departments. That is, the "other possible quality indicators" are "subjective." One important conclusion is that "objective measures might substitute for the collection of reputational data on quality" only if "a large enough range of data is collected to cover all of the measures that might be important in discriminating within different fields and disciplines. Since different objective indicators were the most important discriminants or correlates of quality in different fields, there is no assurance that any particular list of variables would be adequate to predict quality across all fields and disciplines." See also papers by Knudsen and Vaughan and by Moore (Sec. VII.).

Cartter, Allan M., An Assessment of Quality in Graduate Education (Washington, D.C.: American Council on Education, 1966). Kennedy School of Government Library LB2371 .C35.

Cartter uses expert opinion to rank graduate programs in various disciplines. The report is based on the assumption that "the higher the degree of agreement among expert witnesses, the more likely it is that the opinion represents a fact." See also critiques by Knudsen and Vaughan and by Bayer and Snipper (both in this section).

Dawes, Robyn M., "A case study of graduate admissions: Application of three principles of human decision making," American Psychologist, 26 (April 1971): 180-188. File "Education."

Investigates the possibility of screening out clearly unacceptable applicants to graduate departments using

mathematical models of the observed decision-making processes of admission committees.

Knudsen, Dean D. and Vaughan, Ted R., "Quality in graduate education: A re-evaluation of the rankings of sociology departments in the Cartter report," The American Sociologist (Feb. 1969): 12-19. File "Education."

Criticizes the Cartter report for its "subjective evaluations" and attempts to discern the correlation between these and more "objective indicators." The objective indicator used is publications and the authors find that the ranking of the best departments so indicated corresponds closely with that of the Cartter report, while the ranking of departments of lesser quality does not correlate well. See also Moore and Beyer and Snipper (Sec. VII.).

Moore, William J., "The relative quality of graduate programs in economics, 1958-1972: Who published and who perished," Western Economic Journal (1973): 1-23. File "Education."

Uses rather elaborate mathematical models to find that publication rates are highly correlated with the Cartter report's rankings. See also Knudsen and Vaughan, and Beyer and Snipper (Sec VII.).

National Center for Education Statistics, Three National Assessments of Science: Changes in Achievement, 1969-77 (Selected Results from the Third National Assessment of Science), (Denver, Col.: Education Commission of the States, June 1978, Science Report 08-S-00). File "Education."

Summary of major findings: 1/ Overall achievement in science is not declining nearly as quickly as it previous had been; 2/ The achievement of seventeen year-olds, however, continues to decline; 3/ The achievement of students in "extreme-rural communities" is improving; 4/ "A gap continues to exist in the achievement levels of whites and blacks" and "The achievement level of males at each age was higher than that of females."

Schatz, Gerald S., "Science for non-science majors: Problems of quality and quantity," News Report (of the National Academy of Sciences), (March 1982): 3-8. File "Education."

Reviews a report by the National Research Council entitled Science for Non-Specialists: The College Years, published in 1982. Advocates improvement in non-specialist science programs.

Smith, Richard and Fiedler, Fred E., "The measurement of scholarly work: A critical review of the literature," Educational Record, 52 (Summer 1971). File "Measuring Output."

Focuses on the strengths and weaknesses of a survey of faculty conducted by the American Council of Education in 1964 to determine the quality of academic departments. States that "Most ratings of individual faculty members are based on publications," and then goes on to elaborate.

Solso, Robert L., "Recommended readings in psychology during the past 17 years," American Psychologist, 26 (Dec. 1971): 1083-1084. File "Education."

Based on analysis of reading lists.

VIII. Issues involving quantity and quality in particular disciplines, including papers on social indicators. (See also entries in Sec. VI, especially volumes edited by Woolf and by Lerner)

A. Social Indicators

Aborn, Murray, "The short and happy life of social indicators at the National Science Foundation," Items (Newsletter of the Social Science Research Council), 38 No. 2/3 (Sept. 1984). File "Disciplinary."

Historical account of the program on social indicators, which ran from 1971 through 1982, review of perspectives on causes for its demise, and list of major projects funded.

Bohrnstedt, George W. and Borgatta, Edgar F., eds., Social Measurement: Current Issues (Beverly Hills, Cal.: Sage, 1981). Widener L.C. HA29 .S638.

The papers in this volume focus on technical, mathematical issues.

Carley, Michael, Social Measurement and Social Indicators: Issues of Policy and Theory (London: George Allen & Unwin, 1981). Widener L.C. HN25 .C36.

Often takes a historical approach, frequently discussing the literature on social indicators. Chapter titles: Introduction to the scope of social indicators; Definitions and dimensions of social indicators; Social indicator systems; Social theory and models; Social indicators and the policy-making process; National social reporting (focusing on the U.K. and U.S.); Social indicators at the urban level.

Duncan, Otis Dudley, Notes on Social Measurement: Historical and Critical (N.Y.: Russell Sage Foundation, 1984). Widener L.C. HM253 .D86 1984.

Emphasis on historical evolution of social measurement

(beginning with the Greeks). Includes analysis of the development of quantitative methods in the social sciences. Table of contents includes abstracts of chapters, whose titles are: Inventing social measurement; Historical metrology; More inventions (e.g. modern ideas about chance); On scales of measurement; Measurement: the real thing; Psychophysics; Psychometrics; Social measurement: predicaments and practices.

Fox, Karl A., Social Indicators and Social Theory: Elements of an Operational System (N.Y.: John Wiley & Sons, 1974): Chaps. 1 and 2. File "Quality in Philosophy."

Reviews the history (particularly the intellectual history) of the "social indicators movement."

Francis, Walton, "What social indicators don't indicate," Evaluation, 1 (1973): 79-83. File "Disciplinary."

Analysis of several basic difficulties with developing and interpreting quantitative indicators of quality of life.

Lee, Trevor and Marans, Robert W., "Objective and subjective indicators: Effects of scale discordance on interrelationships," Social Indicators Research, 8 (1980): 47-64. File "Disciplinary."

Investigates and attempts to offer explanations for weak relationships between objective and subjective measures of quality of life. "The hypothesis that the relationship between the objective and subjective measures is stronger among individuals whose view of neighborhood size is in line with the relatively large territorial base for objective crime statistics is tested and found to be correct."

Seidman, David, book review of Ben-Chieh Liu, Quality of Life Indicators in U.S. Metropolitan Areas: A Statistical Analysis (N.Y.: Praeger, 1976), in Social Indicators Research, 4 (1977): 97-106. File "Disciplinary."

This is an important piece, together with the reply by Liu and the rejoinder by Seidman, included with the review at the same location in the file. Seidman's "principal contention here is that the production of composite indices of quality of life rests upon, at best, very shaky foundations." He goes on to make specific technical criticisms of the composite indicators that Liu uses, and concludes that "In view of the gross shortcomings of Quality of Life..., the attention it has received can only be considered unfortunate. An atheoretical, ad hoc effort, it is presented in such a way as to lead the unwary to think that some scientific basis underlies the rankings of the [Standard Metropolitan Statistical Areas]."

Shaw, Anthony, "Defining the quality of life," Hastings Center

Report, 7 (Oct. 1977): 11. File "Disciplinary."

Research note on symbolic representation of quality of life using a "formula without numbers."

O'Neill, "Some relevant policy uses of the national longitudinal surveys," Social Indicators Newsletter, No. 18 (Sept. 1983). File "Disciplinary."

Examines the actual and potential applications of the National Longitudinal Survey of Labor Market Experience. The major categories of use which O'Neill discusses are unemployment issues, women's labor force, and aging and retirement. (O'Neill references a study of her own prepared for the Department of Labor, "Women and the labor market: A survey of issues and policies in the United States.") Potential uses mentioned include health, education, and military manpower.

"Poverty is more than being flat broke," interview with Peter Townsend, Professor of Social Policy at the University of Bristol, New York Times, April 11, 1982. File "Disciplinary."

Townsend discusses his "deprivation index," which includes a variety of indicators that cannot be measured in monetary terms.

White, Howard D., "A cocitation map of the social indicators movement," Journal of the American Society for Information Science, 34 (1983): 307-312. File "Disciplinary."

Review of the social indicators literature using cocitation techniques to organize this literature. "The [cocitation] map conforms well with independent reviews of the SI literature, actually illustrating some of the judgements they contain." Includes an excellent, and effectively annotated, bibliography.

B. History

Aydelotte, Quantification in History (Reading, Mass.: Addison-Wesley, 1971). Widener H 4539.71.

Argues for a quantitative appraoch to the study of history. Case study of modern British history.

Servos, John W., "Trends of chemistry," review of Arnold Thackray, et al., Chemistry in America, 1876-1976. Historical Indicators (Boston: Reidel, 1985), Science, 230 (November 15, 1985): 800. File "Disciplinary."

The book reviewed amasses a great deal of quantitative data which apparently indicates that chemistry has been in decline for some time, relative to other disciplines. The

authors of the book are dedicated to quantitative history and do it well, but Servos wishes "they had been less ruthless in suppressing their interpretative instincts and more forthcoming in discussing those issues which...give those data meaning."

Thackray, Arnold, "Measurement in the historiography of science," in Elkana, et al., eds., Toward a Metric of Science (N.Y.: Wiley, 1978): 11-30.

Investigates the value of quantitative methods for the history of science and for contemporary attempts to measure science.

C. Health

Baumann, Barbara, "Diversities in conceptions of health and physical fitness," Journal of Health and Human Behavior, 2 (Spring 1961): 39-46. File "Disciplinary."

Discusses various conceptions of physical health.

Comroe, Julius H., Jr. and Dripps, Robert D., "Scientific basis for the support of biomedical science," Science, 192 (April 9, 1976): 105-111, File "Disciplinary."

See Garfield entry, "How can we prove the value of basic research?" (Sec. II.) for discussion.

Culyer, A.J., Measuring Health: Lessons for Ontario (Toronto: University of Toronto Press, 1978): Chap. 2, "Indicators and indexes: An overview." File "Disciplinary."

A theoretical approach, focusing on events in Canada.

Grogono, A.W. and Woodgate, D.J., "Index for measuring health," The Lancet (Nov. 6, 1971): 1024-1026. File "Disciplinary.

"A health index is described which expresses health numerically between 0 and 1. Each patient scores 0, 1/2, or 1 for each of ten 'questions' relating to well-being."

Leeper, Pepper, "Which disease? What vaccines? How to set priorities," News Report (of the National Academy of Sciences), 35 (Dec. 1984-Jan. 1985): 4-11. File "Disciplinary."

Includes section on "non-quantitative factors."

Marshall, Eliot, "Psychotherapy faces test of worth," Science, 207 (Jan. 4, 1980). File "Disciplinary."

Discusses the politics of the psychotherapy community attempting to measure the benefits of its treatment in order

to qualify for Medicare reimbursement.

Miller, James E., "An indicator to aid management in assigning program priorities," Public Health Reports, 85 (August 1970): 725-731. File "Disciplinary."

Develops a quantitative indicator of the effect of public health programs on the health of a population.

United States Congress, Office of Technology Assessment, Medicare's Prospective Payment System: Strategies for Evaluating Cost, Quality, and Medical Technology (Washington, D.C.: USGPO, October 1985). Report Brief in File "Disciplinary."

The report includes both substantive and methodological dimensions.

D. Policy Evaluation

Glaser, Edward M. and Blacker, Thomas E., "Outline of questions for program evaluators utilizing the clinical approach," Evaluation, 1 (Fall 1972): 56-60. File "Disciplinary."

Basic summary of policy evaluation. One short section on "Methods of Measurement," discussing appropriateness of "objective" or "subjective" techniques.

House, Peter W. and Shull, Roger D., The Rush to Policy: Using Analytic Techniques in Public Sector Decisionmaking (privately published, circa 1982). R. Stowe's library.

The authors, who at the time of publication were in the Division of Policy Research and Analysis at the National Science Foundation, describe various analytical techniques and specify their strengths and weaknesses. Included are discussions of the the interaction between political and analytical components of policy-making. Chapter titles: Quantitative techniques; Benefit-cost analysis; Risk analysis; Decision analysis; Practicability, relevance, and compatibility of quantitative decision models; Constitutional and bureaucratic framework; Theory and process of decisions; Policy in practice; Making room for analysis in the political process.

Houston, Tom R., Jr., "The behavioral sciences impact-effectiveness model," in P.H. Rossi and W. Williams, eds., Evaluating Social Programs: Theory, Practice, and Politics (N.Y.: Seminar Press, 1972): 51-65. Paper in file "Disciplinary." Book at Widener Soc 562.716.10.

Summary of techniques for and approaches to policy evaluation. Discusses experimentation and "preexperimental designs" for evaluating policy in some detail. Although problems with experimental evaluation of policy are

discussed, Houston concludes that it is "a powerful model for evaluation."

Patton, Michael Quinn, Qualitative Evaluation Methods (Beverly Hills, Cal.: Sage, 1980). H62 .P3218.

Includes discussion of the relative merits of quantitative and qualitative approaches.

Yin, Robert K., et al., "The difference that quality makes: The case of literature reviews," Sociological Methods & Research, 5 (Nov. 1976): 139-156. File "Measuring Output."

Investigates and attempts to operationalize two intrinsic measures of quality in research on innovation in public policy: "the degree to which both the intervention process and its outcomes were measured with reliable and valid instruments," and "the degree to which the evaluation study followed the paradigm for experimental research..." This is not a study of literature reviewing per se (cf. Light and Pillemer, Cook and Leviton [Sec. II.]). It is rather a study of how to measure the quality of individual research projects which might be included in reviews.

E. Miscellaneous

Brooks, Harvey, "The military innovation system and the qualitative arms race," Daedalus, 104, No. 3 (Summer 1975): 75-97. Shelf.

Discusses the impact of technological innovation on the "world military balance." Concludes in part that "the most promising lines of action for controlling the qualitative arms race probably lie in mutually agreed limitations on testing, including limits on the number of permissable launchers, and on a comprehensive nuclear-test ban."

De Millo, Richard A., et al., "Social processes and proofs of theorems and programs," Communications of the ACM, 22 (May 1979): 271-280. File "Disciplinary."

A philosophically reflective discussion of the difficulties involved with mathematically proving the correctness of computer programs. The authors state that "...in the end, it is a social process that determines whether mathematicians feel confident about a theorem--and we believe that, because no comparable social processes can take place among program verifiers, [a rigorous approach to] program verification is bound to fail.

Glaser, Barney G. and Strauss, Anselm L., The Discovery of Grounded Theory: Strategies for Qualitative Research (Hawthorne, N.Y.: Aldine, 1967). Gutman Education Library HM48 .G43.

Guide for researchers in the social sciences, with some reflection on the relationships between and complementarity of quantitative and qualitative data.

Holmfield, John D., "Science indicators and other indicators: Some user observations," 4S (Society for Social Studies of Science) Newsletter, 3 (Fall 1978): 36-43. File "Science Indicators."

The author is on the staff of the House Committee on Science and Technology. "In this paper the focus will be on the lessons and insights that have been learned from the development and use of indicators in a number of other fields and their applicability to SI." Discusses various sorts of indicators (e.g. of water quality, housing quality).

Jones, Lyle V., "The assessment of scholarship," in E.H. Loveland, ed., Measuring the Hard-to-Measure, No. 6 in the series New Directions in Program Evaluation (San Francisco: Jossey-Bass, 1980). File "Measuring Output."

Reviews several criteria of the quality of an academic researcher's work: number of publications, citation indexing, peer judgements, and awards and honors. Includes a brief section entitled "Evaluating scholarship in the performing arts. Useful summaries of the literature on each of these topics.

Juster, F. Thomas, "Alternatives to GNP as a measure of economic progress," in U.S. Congress, Joint Economic Committee, U.S. Economic Growth From 1976 to 1986: Prospects, Problems, and Patterns, Vol. 10, The Quality of Economic Growth (Washington, D.C.: USGPO, May 20, 1977): 12-24. File "Disciplinary."

Suggests improvements in the measures derived from the National Income and Product accounts, but also concludes that "significant dimensions of both economic growth and economic welfare are basically perceptual rather than objective, and no transformation or modification of the present structure of Accounts is able to incorporate these types of data." This volume also includes a paper by N. E. Terleckyj on "Economic growth and the quality of life."

Kemeny, John G., "Mathematics without numbers," in Lerner, ed. (Sec. VI).

Discusses semi-quantitative mathematical approaches to the social sciences.

Rogerson, William P., "Reputation and product quality," California Institue of Technology, Division of the Humanities and Social Sciences, Social Science Working Paper No. 330, July 1980. File "Disciplinary."

Economic analysis of a market characterized by "quality uncertainty" with respect to products.

IX. Sociology of science (including scientific communication)

Ben-David, Joseph, "The profession of science and its powers," Minerva, 10 (July 1972): 362-383. File "Sociology of Science."

Concludes that "scientists and the scientific community can only participate in the still inadequately understood processes of using scientific research for the solution of practical problems. Claims for exclusiveness of their expertise, for an exclusively professional control over the allocation of funds and the execution of projects with such ends in view might bring short-run benefits for science. They are unlikely to serve the long-range objective of making research an increasingly more useful tool for man."

Chubin, Daryl E., "State of the field: The conceptualization of scientific specialties," The Sociological Quarterly, 17 (Autumn 1976): 448-476. File "Sociology of Science."

The paper "analyzes the phenomenon of research specializtion in science. The format consists of two sections. The first features a state-of-the-art review of evidence from so-called specialty case studies on definitions, measurement strategies, and representations of the relations in which small groups of researchers cohere. In the second section, a theoretical perspective on the development of specialties is formulated. This perspective...suggests...that core researchers derive innovations from the margins of their specialty. It is further hypothesized that both maintenance and realignment of social structures, i.e. communication and status configurations, depend on intellectual events that occur in the course of normal scientific progress."

Cole, Stephen, "Age and scientific performance," American Journal of Sociology, 84 (Jan. 1979): 958-977. File "Sociology of Science." (See also article in this section by Gillmor.)

The authors conclude that "The long-standing belief that age is negatively associated with scientific productivity and creativity is shown to be based upon incorrect analysis of data."

Cole, Stephen, "The growth of scientific knowledge: Theories of deviance as a case study," in L.A. Coser, ed., The Idea of Social Structure: Papers in Honor of Robert K. Merton (N.Y.: Harcourt Brace Jovanovich, 1975). Paper in File "Sociology of Science"; book in Social Relations Library HM24 .I34.

Uses Merton's theory of deviance (social structure and anomie) and subsequent literature on deviance "as a research

site to explore the social processes through which knowledge grows and ideas change." Cole builds on the work of Thomas Kuhn, who "has concluded that, ultimately, the process through which ideas change and develop can be understood only through sociological analysis." The author outlines "some of the problems raised by Kuhn and then, using the field of deviance research as an example," illustrates "how we might go about empirically investigating a few of these problems." This investigation relies on citation analysis.

Cole, Stephen, "Professional standing and the reception of scientific discoveries," American Journal of Sociology, 76 (Sept. 1970). File "Sociology of Science."

Tests the hypothesis that "if the Matthew Effect were to operate, the reception of papers of equal quality should be influenced by the location of their authors in the stratification system." Measures quality with citations. Cole finds that, for the most part, the hypothesis is not supported by the data.

Cole, Stephen and Cole, Jonathan R., "Scientific output and recognition: A study in the operation of the reward system of science," American Sociological Review, 32 (June 1967): 378-390. File "Citations." COZZENS.

Studies "The relationship between the quantity and quality of scientific output of 120 university physicists. Although these two variables are highly correlated, some physicists produce many papers of little significance and others produce a few papers of great significance." Quality is measured by citations, using SCI.

Elzinga, Aant, "The Swedish science discussion 1965-1975," Social Indicators Research, 7 (1980): 379-399. File "Sociology of Science."

Author's abstract: "During the 1960's, in Sweden...GNP was taken as an indicator of scientific growth. Today the science policy discussion is more centered around the question of political direction of science in accordance with social goals...This change of science policy doctrine reflects important modifications in the social conditions for the production of scientific knowledge." The paper discusses these propositions in light of future studies, controversy over science, and trade union interest in science policy.

Fisher, Charles S., "The last invariant theorists: A sociological study of the collective biographies of mathematical specialists," Archives Europennes de Sociologie, 8 (1967): 216-244. File "Sociology of Science." (See also entry under Chubin in Sec. II. on collective biography.)

The author takes "the perspective of the sociology of

knowledge" and tries to "describe the disappearance of a mathematical theory. Although accepting that the "intellectual content of a theory" is the basis of "one way of describing occurences within science," he chooses to view science as "as an activity carried on by the men who create the scientific ideas."

Garvey, William D. and Griffith, Belver C., "Scientific communication: Its role in the conduct of research and creation of knowledge," American Psychologist, 26 (April 1971): 349-362. File "Sociology of Science."

Discusses problems with scholarly communication in the field of psychology and possible solutions to these problems.

Gilbert, G. Nigel, "Referencing as persuasion," Social Studies of Science, 7, No. 1 (Feb. 1977): 113-122. File "Sociology of Science." COZZENS.

The author considers "scientific papers as 'tools of persuasion.' A scientist who has obtained results which he beleives to be true and important has to persuade the scientific community...to share his opinions of the value of his work. For it is only when some degree of consensus has been achieved that his research findings will be transformed into scientific knowledge."

Gilbert, G. Nigel, "The transformation of research findings into scientific knowledge," Social Studies of Science, 6 (1976): 281-306. File "Sociology of Science." COZZENS.

The paper is concerned with "the process whereby a scientist's research findings are transformed into accredited factual knowledge...with the 'context of justification'...In contrast to the epistemological concerns of the philosophers," the author considers "only the procedures actually used by the natural scientists to decide on the validity of claims to scientific knowledge."

Gillmor, C. Stewart, "Aging of geophysicists," Eos, 65 (May 15, 1984): 353-354. File "Sociology of Science." (See also article in this section by S. Cole.)

Does not look at productivity, but rather at the causes for the aging of the population of geophysicists.

Gustin, Bernard H., "Charisma, recognition, and the motivation of scientists," American Journal of Sociology, 78 (March 1973): 1119-1134. File "Sociology of Science."

"Desire for recognition is a theoretically and empirically inadequate key to the motivation of scientists. A large proportion of the scientific community publishes very little. The elite, prolific scientists are neither dependent on nor rewarded for the publication of their

research, and most work by average scientists is hardly ever acknowledged, much less rewarded, with citations and prizes. Charisma is proposed as a complemetary basis for an explanation of scientific motivation...

Merton, Robert K., Foreword to E. Garfield, Citation Indexing: Its Theory and Application in Science, Technology, and Humanities (John Wiley & Sons, 1979; reprinted in Current Contents). File "Citations."

Review of citation analysis from the point of view of sociology of science.

Merton, Robert K., "The Matthew Effect in Science," Science, 159 (Jan. 5, 1968): 56-63. File "Sociology of Science."

Suggests that those scientists who achieve early success tend, for that reason, to enhance their chances of future success. That is, rewards in the scientific community are allocated preferentially to those who have already gained a measure of prominence.

Mulkay, Michael, "Applied philosophy and philosophers' practice," Science, Technology, & Human Values, 6 (Winter 1981): 7-15.

Critiques papers in the previous issue of STHV, which was partly on applied philosophy of science. (See paper by Shrader-Frechette in Sec. VI.) The author is a sociologist and his theme, put simplistically, is that both scientists and philosophers practice within social groups, that their practice differs, and that these differing practices affect epistemological or analytical approaches. In order to "influence others' actions," applied philosophers "might have to engage actively in the social life of their subjects [scientists]...instead of relying almost exclusively on analysis of the general structure of scientsts' intellectual accomplishments."

Mulkay, M.J., "Three models of scientific development," The Sociological Review, 23 (August 1975): 509-526. File "Sociology of Science."

This is a historically-oriented sociological attempt to construct three alternative models of scientific development: models of "openness," "closure," and "branching." With a reply by John Parker.

Reif, Fred and Strauss, Anselm, "The impact of rapid discovery upon the scientist's career," Social Problems, 12 (Winter 1965): 297-311. File "Measuring Output."

Account of successful scientists' career paths.

Singer, Barry F., "Toward a Psychology of Science," American Psychologist, 26 (Nov. 1971): 1010-1015. File "Sociology of

Science."

Builds on S.S. Stevens' early work on "science of science." Attempt to blend "psychology, science, and philosophy of science."

Zuckerman, Harriet, "Theory choice and problem choice in science," Sociological Inquiry, 48 (1978): 65-95. File "Sociology of Science."

Reviews "current sociological and philosophical work bearing upon cognitive change [in science]." Finds that scientists' behavior corresponds but little to "epistemological prescriptions of how they should behave," but "corresponds more than one might suppose to often stated methodological precepts which give primacy to assessed significance and feasibility of solution."

X. Methodological papers and bibliographies (see the introduction for the more important bibliographies)

Glaser, Edward M. and Blacker, Thomas E., "Outline of questions for program evaluators utilizing the clinical approach," Evaluation, 1 (Fall 1972): 56-60. File "Disciplinary."

Basic summary of policy evaluation. One short section on "Methods of Measurement," discussing appropriateness of "objective" or "subjective" techniques.

Guttman, Louis, "A basis for scaling qualitative data," American Sociological Review, 9 (April 1944): 139-150. File "Bibliography and Methodology."

Source of the "Guttman Scale."

Hahn, Roger, A Bibliography of Quantitative Studies on Science and its History (Berkeley, Calif.: University of California at Berkeley, Berkeley Papers in History of Science, No. 3, 1980). Shelf.

Henwood, Felicity and Thomas, Graham, Science, Technology, and Innovation: A Research Bibliography (Brighton, U.K.: Wheatsheaf Books/Harvester Press, 1984), Chapter 1, "Measurement of science and technology." File "Bibliography and Methodology."

Lists primarily, but not exclusively, statistical publications of governments and international organizations; all entries are held by the Science Policy Research Unit of the University of Sussex.

Holton, Gerald and Sopka, Katherine, "Great books of science in

the twentieth century: Physics," in Great Ideas Today: 1979 (Chicago: Encyclopedia Britannica, 1979): 225-277. File "G. Holton Papers."

McFadden, Daniel, "Conditional logit analysis of qualitative choice behavior," Chap. 4 in P. Zaremska, ed., Frontiers in Econometrics (N.Y.: Academic Press, 1974): 105-142. "Bibliography and Methodology."

Only the introduction and conclusion are filed.

Social Science Research Council, Center for the Coordination of Research on Social Indicators, "Statistical data on science collected by federal agencies--A draft bibliography," prepared by R.B. Miller, April 22, 1977. File "Bibliography and Methodology."

Sussex, University of, Science Policy Research Unit, "Recent SPRU work on research evaluation," 1985. File "Bibliography and Methodology."

Vetter, Betty M. and Jensen-Fisher, Susan, Guide to Data on Scientists and Engineers (Washington, D.C.: Scientific Manpower Commission, April 1984). Shelf.

Includes three indexes. The first is organized by publisher. The publishing organization (about 50 are listed) is described, as well as that organization's "manpower surveys." The second organizes publications according to field, the third by year of publication.

XI. Access of women to participation in scientific research

All entries are in project file "Access to Science" unless noted otherwise.

For further references, see also the following papers, which have especially useful bibliographies. (See below for full cites of these two papers.)

Berryman, Sue E., Who Will Do Science?

Cole, Jonathan R. and Zuckerman, Harriet, "The productivity puzzle."

American Association for the Advancement of Science, Office of Opportunities in Science, "Associations and committees of or for women in science, engineering, mathematics and medicine," compiled by Alicia E. Leach and Michele Aldrich (AAAS Publication 84-6, December 1984). Shelf.

A compilation of information on women's groups by field; includes the social sciences. Each entry includes contacts, with address and phone number, membership, publications, current activities, and future plans. Copies can be obtained from AAAS, Office of Opportunities in Science, 1776 Massachusetts Avenue, Washington, D.C. 20036.

Astin, Helen S., "Academic scholarship and its rewards," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 259-279. Shelf.

Astin states in her abstract that "This paper challenges a frequent conclusion that women faculty lag behind their male counterparts because of their lower research output." She specifically contrasts the findings of her research, which takes into account factors such as marital status, age, and characteristics of graduate institution and employer institution, with those of J. R. Cole in his book, Fair Science (see below).

Astin, Helen S., "Factors affecting women's scholarly productivity," in Helen S. Astin and Werner Z. Hirsch, eds., The Higher Education of Women (New York: Praeger, 1978): 133-57.

This article investigates the reasons why women scientists produce less published research. The author identifies several important variables related to productivity. She finds that marriage is positively correlated with productivity.

Astin, Helen S., The Woman Doctorate in America: Origins, Career,

and Family (New York: Russell Sage Foundation, 1969). Widener Soc 5085.169.

One of the first studies performed on women scientists using original data and rigorous social scientific methods. A principal conclusion is that marriage and child-rearing may delay to some extent, but do not qualitatively inhibit career achievement. Includes discussions of demographic characteristics, early career choices, work patterns, occupational rewards, family life, obstacles to professional advancement, and several autobiographical sketches.

Astin, Helen S. and Bayer, Alan E., "Pervasive sex differences in the academic reward system: Scholarship, marriage, and what else?" Chapter 10 in Darrell R. Lewis and William E. Becker, Jr., eds., Academic Rewards in Higher Education (Cambridge, Mass.: Ballinger Publishing Co., 1979): 211-29.

The authors study sex differences with respect to rank and salary. They find discrimination to be a significant factor in determining the observed lower rank and earnings of women. They suggest that married women, whose earnings and rank are more on a par with men than single women, may be discriminated against less because of social norms favoring women who have the married status.

Astin, Helen S. and Hirsch, Werner Z., eds., The Higher Education of Women: Essays in Honor of Rosemary Park (N.Y.: Praeger Publishers, 1978). Widener L.C. LC.1567 H53.

Includes a number of anecdotal accounts and qualitative analyses. See also entries under Astin and under Hirsch and Hirsch in this section.

Bachtold, Louise M. and Werner, Emmy E., "Personality profiles of gifted women: Psychologists," in Eiduson, Bernice T. and Beckman, Linda, eds., Science as a Career Choice (New York: Russell Sage Foundation, 1973): 551-63. Shelf.

The authors find that their sample differs from "adult women in general and from women college students in many of the same personality characteristics on which they resemble academic men." They also discuss data on publication and work patterns of developmental, counseling, and clinical psychologists.

Bayer, Alan E. and Astin, Helen S., "Sex differentials in the academic reward system, "Science, 188 (May 23, 1975): 796-801.

The authors assess the progress of women scientists since the implementation of federal antibias regulations in the early 1970s. Comparison of expected (on the basis of productivity) rewards and actual rewards reveal significant differentials, which are seen to be the result of continuing sex bias, though this bias is thought to be

less than five years earlier. Astin and Bayer's 1979 paper (above) builds upon this one.

Benbow, Camilla Persson and Stanley, Julian C., "Gender and the science major: A study of mathematically precocious youth," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 165-96. Shelf.

Studies seventh and eighth grade students with unusually high aptitude for math; more girls than boys among these students later took high school physics, and the boys scored higher on standardized tests in the natural sciences. The authors conclude only that some of the difference can be accounted for "by the females' lower mathematical reasoning ability in the seventh and eighth grade," although all of the mathematically precocious youth had a more enthusiastic attitude toward science.

Berryman, Sue E., Who Will Do Science? (New York: Rockefeller Foundation Special Report, November 1983). Shelf.

Comprehensive study of women and minorities based on a considerable body of data; includes relatively elaborate attempt to model and explain female and minority underrepresentation in the sciences. See also entry under Scientific Manpower Commission.

Blackburn, Robert T., Behymer, Charles E., and Hall, David E., "Research note: Correlates of faculty publications," Sociology of Education, 51 (January 1978): 132-41.

The authors survey a large group of faculty members (1,216) to ascertain the correlates of published productivity. They study faculty in both the sciences and the humanities and find some distinctive patterns in the two fields. However, they find that across fields professors in smaller teaching colleges publish less than their counterparts in large research-oriented universities. They also find that "Those who will be productive over their full careers are the individuals who start early, receive their degrees when young, and take on the habit of regular output." The authors find that "sex is not a significant predictor" of productivity. They go on to suggest in a footnote, however, that discrimination may account in part for women's lower productivity.

Bruer, John T., "Women in science: Toward equitable participation," Science, Technology, & Human Values, 9 (Summer 1984): 3-7. WOM.

A brief review of recent Macy Foundation activities with respect to women in science, including an account of quantitative and qualitative research by J.R. Cole and H. Zuckerman.

Brush, Stephen G., "Women in physical science: From drudges to discoverers," The Physics Teacher (January 1985): 11-19.

A short essay including biographic portraits of 10 outstanding women scientists.

Carnegie Institution of Washington, James D. Ebert, President, "Report of the President: 1982-1983." Shelf.

Includes a section on the work of Barbara McClintock, who received support from the Carnegie Foundation and won the Nobel Prize during the year covered by this report.

Centra, John A., Women, Men and the Doctorate (Princeton, N.J.: Educational Testing Service, 1974). Widener Soc 5085.174.25.

This is a large-scale study of women with doctorates based on a questionnaire survey (sample size: 3,068 men and women). The researchers gather data on careers of women and men: promotion history, interests in teaching and research , marital and family status, publication rates, etc. Subjects were also asked about their graduate school experiences and their attitudes toward women's rights. Centra concludes by defining four types of female career paths, the distinctions between which are largely determined by cultural tradition, sex role expectations, and discriminatory practices.

Chubin, Daryl, "Sociological manpower and womanpower: Sex differences in career patterns of two cohorts of American doctorate sociologists," The American Sociologist, 9 (May 1974): 83-92. COZZENS.

Studies demographics, research performance, and mobility of men and women. Finds that "the structure of [sociological] employment militated against women sociologists receiving recognition by discouraging their mobility to the prestigious Ph.D. granting sector. At the same time, the vehicle for attaining a job in this visible sector--published research--was underutilized." Chubin suggests that this was due to subtle discrimination in graduate school and in the profession.

Cole, Jonathan R., Fair Science: Women in the Scientific Community (New York: The Free Press, 1979). Kennedy School Library Q.130 C64.

A study of sex discrimination in science. (The book does not try to determine the causes of women's lower productivity.) Cole concludes that discrimination against academic women scientists is probably a significant factor only with respect to promotion to the tenured faculty ranks. (See also the review by Roark, listed below.)

Cole, Jonathan R. and Cole, Stephen, Social Stratification in Science (Chicago: University of Chicago Press, 1973). Cabot

Library HM.38 C65.

Includes a chapter on women and minorities in science, and possible discrimination against them.

Cole, Jonathan R. and Cole, Stephen, "The reward system of the social sciences," in Charles Frankel, ed., Controversies and Decisions, (New York: Russell Sage Foundation, 1976): 55-88.

The Coles investigate the extent to which scientists are discriminated against in academic settings on the basis of their social status, including sex. In this early article, the authors state their inability to explain sex-based productivity differentials and find that discrimination is not a factor in the granting of financial support for women and men's graduate study.

Cole, Jonathan R. and Zuckerman, Harriet, "The productivity puzzle: Persistence and change in patterns of publication of men and women scientists," in M.W. Steinkamp and M.L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 217-58. Shelf.

An important piece of research on productivity differentials between men and women scientists. However, the authors do not explain productivity differences; they only show that they have persisted over the last several decades with very little change in magnitude. They offer suggestions for further research.

Diamond, Diana, "Study shows grad women have less self-confidence, despite high marks," Campus Report (Stanford University), Nov. 14, 1984.

Summarizes a study conducted by Larraine Zappert of Stanford.

Eccles (Parsons), Jacquelynne, "Sex differences in mathematics participation," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 93-137. Shelf.

An extended analysis of the factors contributing to girls' choosing to study math less frequently than boys; attempts to place the data within the context of psychological theory.

Epstein, Julia L., Review of Vivian Gornick, Women in Science: Portraits from a World in Transition, in Isis, 75 (1984): 578-79.

"The strength of Women in Science emerges from the indivdual voices of those Gornick interviews...Unfortunately, her impressions float free of historical analysis...ultimately the book never fully supports its thesis [that the practice of contemporary science harbors a key to the recent

sociology of feminism]."

Ferber, Marianne and Huber, Joan, "Husbands, wives, and careers," Journal of Marriage and the Family, 41 (May 1979): 315-25.

The authors attempt to determine the extent to which a spouse's level of education affects the careers of Ph.D. recipients. They have a sample of 346 men and 576 women, employed in academia, industry, and elsewhere, who are assigned to four disciplinary categories: physical, biological, and social sciences, and the humanities. They found that for both men and women, marriage to a highly educated spouse is associated with a fertility decline; marriage to a Ph.D. adversely affects a female Ph.D.'s labor-force participation, apparently because of constraints placed upon her due to her husband's need for mobility; and marriage to a Ph.D. adversely affects a male Ph.D.'s published productivity and/or offices held.

Ferber, Marianne A. and Loeb, Jane W., "Performance, rewards, and perceptions of sex discrimination among male and female faculty," American Journal of Sociology, 78 (January 1973): 995-1002.

The authors use bivariate correlations in this study of women and men faculty members (scientists and others) at the University of Illionois, Champaign- Urbana. They found that marriage and children did not affect the productivity of women faculty members (where productivity is operationalized as publications of various kinds). Marital and parental status is correlated with higher salaries for men, possibly because of perceived financial need on the part of employers. Perception of discrimination seemed to be more accurate among women than men (i.e. women had more awareness of "salary and rank inequities").

Florman, Samuel C., "Will women engineers make a difference?" Technology Review, 87 (November/December 1984): 51-52. Under Tech. Rev. in file.

An essay on women in engineering, suggesting that because they "bring a new dimension to the profession...a more philosophical and aesthetic concern," and because of their broader view and better communication skills, it is in society's interest to encourage women to become engineers.

Fox, Lynn H., The Problem of Women and Mathematics: A Report to the Ford Foundation (New York: Ford Foundation, March 1980). In project file (not on project shelf.)

Discusses sex differences in mathematics, influence of teachers, counselors, and parents, factors affecting career choice, suggestions for future research, and recommendations with respect to educational policy.

Frank, Robert H., "Family location constraints and the geographic

distribution of female professionals," Journal of Political Economy, 86 (February 1978): 117-30.

Essentially a variation of Frank's article in American Economic Review (see below). Discusses implications for public policy.

Frank, Robert H., "Why women earn less: The theory and estimation of differential overqualification," American Economic Review, 68 (June 1978): 360-373. Widener.

This is a mathematical formalization of the job location process for two-career married couples. The author analyzes the consequences of the tendency of married couples to maximize the husband's professsional potential by choosing to locate themselves in geographic region in which he has found his best job. This results in the differential overqualification of professional women. See also the article by Marwell, et al. and by Rosenfeld (1981), and book edited by Pepitone-Rockwell (all in this section).

Frieze, Irene Hanson and Hanusa, Barbara Hartman, "Women scientists: Overcoming barriers," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 139-63. Shelf.

Studies barriers which women confront, from secondary school through professional work, with respect to careers in science; includes a discussion of possible factors involved with women scientists' lower productivity such as family obligations and differential access to informal social networks.

Garfield, Eugene, "The 1983 Nobel Prizes. Part 2. Myth or reality: Premature discovery is not the same as being ignored! Barbara McClintock and the Prize in Medicine," Current Contents (Feb. 18, 1985): 3-10.

Critiques Evelyn Fox Keller's biography of McClintock. (See below.)

Garfield, Eugene, "The 1986 NAS Award for Excellence in Scientific Reviewing goes to Virginia L. Trimble for her reviews in astronomy and astrophysics," Current Contents (May 12, 1986): 4-11.

Discusses Trimble's work in citation analysis as well as her research and reviewing in astronomy and astrophysics.

Garfield, Eugene, "Why aren't there more women in science?" Current Contents (April 26, 1982): 5-12.

A brief account of some recent research in the field, with a list of the 27 most-cited female scientists for the period 1965-1978, with their affiliations.

Graham, Patricia Albjerg, "Women in academe," Science, 169 (September 25, 1970): 1284-90.

A review of some of the problems faced by female academics in the late 1960s; includes a historical account of women in universities in the U.S.

Grieb, Aimée and Easley, Jack, "A primary school impediment to mathematical equity: Case-studies in rule-dependent socialization," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 317-362. Shelf.

Through case studies of elementary school students, the authors attempt to "identify a social mechanism in primary schools which allows white, middle-class male students who are creative in their study of mathematics to preserve an independent attitude while keeping females and minorities in an attitude of dependence on knowing the algorithm before proceeding with the problem."

Haas, Violet B. and Perrucci, Carolyn C., eds, Women in Scientific and Engineering Professions (Ann Arbor, Mich.: University of Michigan Press, 1984). Shelf.

A collection of papers presented at the Conference on Women in the Professions: Science, Social Science, Engineering, held at Purdue University in March 1981. The piece is by Rosenfeld is included below.

Hansen, W. Lee, Weisbrod, Burton A. and Strauss, Robert P., "Confirmations and contradictions: Modeling the earnings and research productivity of academic economists," Journal of Political Economy, 86 (October 1978): 729-41.

The paper does not focus on male-female differentials, but is relevant to the issue as it provides a useful economic analysis of earnings. The authors conclude that published productivity has a much greater effect on earnings than previous studies have suggested.

Hargens, Lowell L., McCann, James C., and Reskin, Barbara F., "Productivity and reproductivity: Fertility and professional achievement among research scientists," Social Forces, 57 (September 1978): 154-63.

Directly addresses the question of whether having children affects the published productivity of a group of research chemists; the authors find that both women and men display decreased productivity after having children, to approximately the same degree. Note that Reskin (American Journal of Sociology, 1978) apparently uses approximately the same data set but finds no relationship between family responsibilities and productivity, either negative or

positive.

Harnisch, Delwyn L., "Females and mathematics: A cross-national perspective," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 73-91. Shelf.

Analyzes data on sex-differences in mathematics for women in Japan, Sweden, and the United States.

Harway, Michele and Astin, Helen S., Sex Discrimination in Career Counseling and Education (N.Y.: Praeger, 1977). Widener L.C. LB1027.5 .H355 1977.

Comprehensive and very useful account of the early socialization process of female high school students and of sex bias on the part of counselors; does not focus on science in particular, but see entries for "mathematical ability" and "mathematics and science: importance of high school preparation in" in the index.

Helmreich, Robert L., Spence, Janet T., et al., "Making it in academic psychology: Demographic and personality correlates of attainment," Journal of Personality and Social Psychology, 39 (1980): 896-908.

An important article, referenced favorably by Cole and Zuckerman in their recent work (see above), which includes data on sex differences among academic psychologists. The authors had a sample of 141 male and 55 female psychologists, to whom they administered two measures of relevant personality variables, and for whom they collected publication, citation, and demographic data. They develop a relatively complex causal model of attainment in psychology on the basis of their data in which sex, quality of graduate school, and quality of current school are causal to attainment. In addition, certain motivational atrributes have an effect on productivity and attainment. The usual sex differences in productivity were observed. Marital and family responsibilities were not seen to affect productivity. Measured personality differences did not account for productivity differences, either. The authors speculate that social-psychological factors which they did not study may be important in this regard, such as isolation of women from informal collegial networks and citation biases on the part of publishing psychologists. Interestingly, the authors suggest that "The substantial differences between men and women in attainment measures, particularly in citations, may...represent the aggregate effects of a large number of relatively independent and/or interactive causes, each quite minor when considered by itself."

Helson, Ravenna, "Women mathematicians and the creative personality," in Eiduson, Bernice T. and Beckman, Linda, eds.,

Science as a Career Choice (New York: Russell Sage Foundation, 1973): 563-74. Shelf.

The authors compare creative women mathematicians with other women holding Ph.D.'s in mathematics. Their sample includes 45 women, of whom the 18 "creative" individuals are "virtually all of the creative women mathematicians in the United States." The authors identify several personality traits characteristic of the creative mathematicians, but do not believe that they have different sorts of cognitive abilities than the other women in the sample. A central question in the study is "how a woman could so suppress her feminine nature to be a mathematician without suppressing her originality also." They tentatively answer that women mathematicians are introverts but, more importantly, the creative women are able to express themselves freely in their work, "with emotional involvement."

Hirsch, Hilde E. and Hirsch, Werner Z., "Intellectual quality: The symbols and the substance," in Helen S. Astin and Werner Z. Hirsch, eds., The Higher Education of Women (New York: Praeger, 1978): 161-65.

An essay on intellectual quality; emphasizes in particular the inadequacy of quantitative measures, especially citation counts, as a measure of academic ability, and suggests that "women and minorities are likely to suffer from a reliance on surrogates [indirect, quantitative measures] that often poorly reflect true ability."

Hoffleit, Dorrit, "Confirmed stereotypes transformed to freedom and variety," review of Vivian Gornick, Women in Science: Portraits from a World in Transition, in Physics Today (September 1984): 77-78.

Largely positive; quotes Gornick describing her book as "'impressionistic journalism.'"

Hornig, Lilli S., "Women in science and engineering: Why so few?" Technology Review, 87 (November/December 1984): 30-41. Under "Tech. Rev." in file.

A historical overview of discrimination against women in science and engineering.

Humphreys, Lloyd G., "Women with doctorates in science and engineering," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 197-216. Shelf.

A detailed study of the characteristics of female Ph.D. degree holders and the problems which they have encountered; concludes that men and women "are essentially equal on the general factor in intelligence," and that sex-related differences in certain intellectual skills are

environmentally determined.

Johnson, George E. and Stafford, Frank P., "Pecuniary rewards to men and women faculty," Chapter 11 in Darrell R. Lewis and William E. Becker, Jr., eds., Academic Rewards in Higher Education (Cambridge, Mass.: Ballinger Publishing Co., 1979): 231-243.

This article is an attempt to explain salary differences between men and women faculty members. The authors explore two alternative exlanations for women's lower salaries: 1/ women choose to absent themselves from the labor market, primarily for family reasons, produce less, and thus are paid less; and 2/ women are discriminated against. They find evidence for both, and explore the policy implications which follow from their analysis.

Johnson, George E. and Stafford, Frank P., "Women and the academic labor market," Chapter 8 in Cynthia B. Lloyd, ed., Sex, Discrimination, and the Division of Labor (New York: Columbia University Press, 1975): 201-19.

This earlier article of Johnson and Stafford's is the basis for their 1979 chapter. (See above.) Importantly, they find that "women who are married are most likely to drop out of full-time employment, particularly when preschool-age children are present in the household." He cites Astin's similar findings in The Woman Doctorate in America.

Kaufman, Debra Renée, "Associational ties in academe: Some male and female differences," Sex Roles, 4 (February 1978): 9-21.

An article on social psychological factors involved with acdemic productivity. Kaufman concludes that her "analysis of the collegial-friend relationships among academicians... indicates that female professors, especially unmarried, have fewer males in their collegial-friend networks than men. Whether by choice or exclusion, it is suggested that isolation from these informal collegial contacts leaves women at a profound professional disadvantage." Kaufman does not indicate the disciplinary affiliation of her subjects. They may not be scientists.

Kavrell, Suzanne McNeill and Peterson, Anne C., "Patterns of achievement in early adolescence," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 1-35. Shelf.

Studies the possible roots of sex-related differences with respect to science; suggests that during the period between sixth and eighth grades, girls with aptitude for science may require special encouragement.

Keller, Evelyn Fox, "Contending with the masculine bias in the

ideals and values of science," The Chronicle of Higher Education (Oct. 2, 1985): 96.

An essay on traditionally feminine modes of inquiry: feeling, identification with nature, love. Argues that these are valuable in the pursuit of knowledge.

Keller, Evelyn Fox, A Feeling for the Organism: The Life and Work of Barbara McClintock (San Francisco: W.H. Freeman, 1983). Cabot Library QH.429.2 M38 K44 1983.

A biography of the Nobel Prize winning biologist, focusing in part on what Keller believes to be the special cognitive abilities women bring to science. See also the Technology Review article by Keller below and the review by Bentley Glass in Isis, 75 (September 1984): 600-601.

Keller, Evelyn Fox, Reflections on Gender in Science (New Haven, Conn.: Yale University Press, 1985).

Investigates the perceptual and epistemological dimensions of the subjective, intuitive, and emotive approach to gaining knowledge usually characterized as feminine.

Keller, Evelyn Fox, "Women and basic research: Respecting the unexpected," Technology Review, 87 (November/December 1984): 44-47. Under Tech. Rev. in file.

Studies possible differences between men and women in epistemological approaches to science; focuses on the work of Barbara McClintock.

Kevles, Daniel J., "Statistical data and the history of women: A critique of Margaret Rossiter's Women Scientists in America: Struggles and Strategies to 1940," California Institute of Technology, Division of the Humanities and Social Sciences, Humanities Working Paper No. 79, March 1983.

Author's abstract: "Rossiter's book...is a goldmine of information. At its core is a statistical data base drawn from succesive editions of American Men in Science... However, Rossiter makes no standard tests of significance of her valuable statistics. More important, she commits the major methodological sin of giving inadequate attention to alternative explanations of the numerical data. The result is that while Rossiter amply documents the considerable discrimination that women faced in the American scientific enterprise, she leaves cloudy the relative force of that discrimination compared to internalized cultural norms, marital and maternal obligations, and the like."

Kolbert, Elizabeth, "Scientific ideas: Women's vs. Men's," New York Times, Oct. 17, 1985, pp. c1, c12.

Review of the work of Ruth Bleier, Ruth Perry, and Evelyn

Fox Keller, who in various ways, on the basis of their research, believe that men and women have different cognitive approaches to science.

Kremer, Barbara K., "The meta-analysis of gender differences in science learning: A first step toward the development of educational policy to encourage women in science," in Marjorie W. Steinkamp and Martin L. Maehr, eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 51-71. Shelf.

Reviews and "meta-analyzes" research on sex-related differences in science and on science education; concludes that carefully planned educational intervention to encourage women's interest in science can be effective.

Long, J. Scott, "Productivity and academic position in the scientific career," American Sociological Review, 43 (December 1978): 889-908.

Long's paper is interesting for the extreme position that it takes. He does not examine women in particular, but rather looks at the relationship between productivity and position in the "academic stratification system." His subjects are biochemists. He concludes from his research that position within the academic system determines productivity more strongly than vice-versa. He suggests that this is true from the very beginning of the academic career. Particularistic, rather than universalistic, factors determine productivity at all points in the academic career. He explicitly argues against Cole and Cole who, in Social Stratification in Science, suggest that accumulative advantage partially accounts for stratification, but that productivity is the dominant factor in determining rewards in the beginning of a scientific career.

Lotze, Barbara, ed., Making Contributions: An Historical Overview of Women's Role in Physics (College Park, Maryland: American Association of Physics Teachers, 1984). Shelf.

Historical accounts of prominent women in physics.

Martin, Ben R. and Irvine, John, "Women in science--the astronomical brain drain," Women's Studies International Forum, 5, No. 1: 41-68. In File "Martin/Irvine." WOM.

The authors wrote this article as part of a long-term study on the evaluation of large-scale basic research in Great Britain. The subjects are all Ph.D. students in radio astronomy in Great Britain, from the emergence of the discipline in 1947 through 1977 (14 women and 301 men). There is an observed discrepancy between the performance of the women in graduate school, which was excellent on average, and their lack of subsequent achievement, relative to the men. The authors conclude that "the lack of relative success...is most likely to be the result of social factors

concerning the role within the family rather than any inherent lack of ability as a scientist or direct discrimination in employment." Specifically, it was found that disproportionate numbers of women radio astronomers dropped out of the scientific work force upon marrying or having children.

Marwell, Gerald, et al., "Geographic constraints on women's careers in academia," Science, 205 (September 21, 1979): 1225-31. Cabot Library.

The authors suggest that when both members of a married couple are seeking professional positions, the couple is more likely to choose the geographic location in which the husband's earnings and potential for career advancement are maximized. Using data they have collected and analyzed, they state that female academics are concentrated in large urban areas. They suggest that this location pattern is due to professional academic wives being able to find a job when their husbands gain academic or other employment in a large city (because there are more jobs available), but being less able to find jobs when their husbands gain employment in universities located in smaller towns. See also articles by Frank and by Rosenfeld (1981), and book edited by Pepitone-Rockwell.

National Academy of Sciences, Climbing the Academic Ladder: Doctoral Women Scientists in Academe (Washington, D.C.: National Academy Press, 1979). Cabot Library Q.130 N37.

A study by the Committee on the Education and Employment of Women in Science and Engineering of the National Research Council on the progress of women in academia during the mid-1970s and their continuing problems with discrimination and, to a lesser extent, other problems leading to imbalanced hiring and promotion practices.

National Academy of Sciences, Climbing the Ladder: An Update on the Status of Doctoral Women Scientists and Engineers (Washington, D.C.: National Academy Press, 1983). Cabot Library Q.130 C54 1983.

An update of the 1979 study by the National Research Council, including data on women scientists and engineers in industry.

National Science Foundation, Women and Minorities in Science and Engineeering (Washington, D.C.: USGPO, Jan. 1977, Jan. 1982, Jan. 1984, Jan. 1986). Shelf.

Data on employment levels and trends, fields of employment, experience, career patterns, and scientific and technical education.

Pepitone-Rockwell, Fran, ed., Dual-Career Couples (Beverly Hills,

Calif.: Sage Publications, 1980). Littauer Library HQ.536 D797.

Compilation of research on the sociology and economics of dual-career couples three sections on 1/ historical development of dual-career couples, 2/ marriage and family issues, and 3/ career issues. See also articles by Marwell and by Frank.

Reskin, Barbara F., "Sex differences in status attainment in science: The case of the post-doctoral fellowship," American Sociological Review, 41 (August 1976): 597-612.

Reskin's principle finding is that for men, the expected relationship between the calibre of doctoral training and graduate school performance, and the prestige of the postdoctoral award, was evident. For women, this relationship was not evident. Two explanations are considered: gender differences in professional commitment and discrimination. Reskin finds evidence for both explanations and finds that they are not mutually exclusive because "regardless of their level of professional commitment, female scientists as a group also may be somewhat more commited to extraprofessional (primarily familial) roles than are men."

Reskin, Barbara F., "Sex differentiation and the social organization of science," Sociological Inquiry, 48, No. 3-4 (1978): 6-37; reprinted in Jerry Gaston, ed., The Sociology of Science (San Francisco: Jossey-Bass, 1978): 6-37.

This article is a literature review and theoretical investigation of women's role in science. Reskin offers no original field research, but does offer some original anecdotal evidence. Her principal argument is that because women's status within the scientific profession is in general lower than that of men (for reasons discussed in the paper), men and women are likely not to interact as full colleagues. Women then may focus on technical duties, consistent with their lower status, and not perform as much original research. See also articles by Widom and Burke and by Kaufman (all in this section).

Reskin, Barbara F., "Scientific productivity, sex, and location in the institution of science," American Journal of Sociology, 83 (March 1978): 1235-43.

Reskin looks at female and male chemists. She attempts to identify determinants of scientific productivity (publication) and how these determinants differ for men and women. She then notes that organizational features of science, rather than gender, which is functionally irrelevant for scientific performance, might be expected to account for differences in the determinants of productivity and in the productivity itself.

Reskin, Barabara F., and Hargens, Lowell L., "Scientific advancement of male and female chemists," Chapter 5 in Rodolfo Alvarez and Kenneth G. Lutterman, eds., Discrimination in Organizations: Using Social Indicators to Manage Social Change (San Francisco: Jossey-Bass Publishers, 1979): 100-22.

This paper is based directly on the 1978 article in the American Journal of Sociology. (See above.) However, the authors discuss discrimination more explicitly as a factor which determines women's position in the organizational structure of science.

Richter, Derek, ed., Women Scientists: The Road to Liberation (London: Macmillan, 1982). Cabot Library Q.130 W67 1982.

A fascinating series of autobiographical accounts, written by eminent women scientists from the following countries: India, U.S., Japan, France, Italy, Iran, Sweden, USSR, U.K., and Kenya. Provides insight into the comparative sociology of science, the conditions under which women work in other countries, and the lives of persistent, adventurous, and successful individuals. The papers were compiled partly in collaboration with the World Health Organization.

Roark, Anne, "Women scientists faring better, study finds," Science and Government Report (December 1, 1979).

A review of Jonathan Cole's book, Fair Science: Women in the Scientific Community (see this section), and a good summary of the major findings. Claims that Cole did not go far enough in advocating affirmative action programs and highlighting the problems of women scientists.

Rosenfeld, Rachel A., "Academic career mobility for women and men psychologists," in Violet B. Haas and Carolyn C. Perrucci, eds., Women in Scientific and Engineering Professions (Ann Arbor, Mich.: University of Michigan Press, 1984): 89-127. Shelf.

Elaboration of article in Social Science Research (see below).

Rosenfeld, Rachel A., "Academic men and women's career mobility," Social Science Research, 10 (December 1981): 337-63.

A study of psychologists' career paths; uses statistical models based in part on Markov processes to analyze employment transitions. The principal conclusion is that women are less likely to follow regular career paths than men. More specifically, Rosenfeld finds that geographic mobility for men seemed to depend on the nature of the job they were leaving, while geographic mobility for women "seemed to be associated only with the size of the labor market they were in." (See also articles by Frank and by Marwell, et al.)

Rossiter, Margaret W., "Women scientists in America before 1920," American Scientist, 62: 312-323. WOM.

The career patterns of 504 women scientists are compared with a control group of men. The women were more educated, were employed more often in academic institutions, were half as eminent, and were more likely to be unemployed.

Rossiter, Margaret W., Women Scientists in America: Struggles and Strategies to 1940 (Baltimore: Johns Hopkins University Press, 1982). Widener L.C. Q130 .R68.

Rossiter uses archival material and other sources to study the history of women in science from the mid-1800's to about 1940. She documents discrimination against women at each stage of the scientific career. According to Barbara Sicherman, "One of Rossiter's principal findings is the prevalence of sex-aggregated and sex-typed work [during the period under study]...' See also the review symposium in Isis, 75 (March 1984): 189-203 and the review article by Kevles (listed in this bibliography, Sec. XI).

Rubin-Rabson, Grace, "Factors in the achievement drive of gifted women," American Psychologist, 26 (February 1971): 205-7.

A research note, in part summarizing other studies on motivation, suggesting that during high school and college years, biological and personal factors are partly responsible for girls lack of motivation and achievement, and that discrimination has been overestimated as a cause of women's problems in higher education and in the professions. The author further suggests that legislation cannot alleviate the biological component of young women's motivational lack.

Scientific Manpower Commission, "The science and engineering talent pool: Proceedings of the 1984 joint meeting of the Scientific Manpower Commission and the Engineering Manpower Commission," May 15, 1984. Shelf.

Includes a presentation by Sue Berryman entitled "The "Underrepresentation of women and minorities in quantitative fields: How does it occurr?"

Steinkamp, Marjorie W., "Motivational styles as a mediator of adult achievement in science," in Steinkamp, Marjorie W. and Maehr, Martin L., eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 281-316. Shelf

Explores possible sources of differences in mathematical ability between men and women; on the motivational styles of young boys and girls; finds that boys' motivational styles are "consonant" with those which are usually seen in scientists and girls', for the most part, are "dissonant"; successful women scientists display motivational

characteristics similar to those more generally representative of men.

Steinkamp, Marjorie W. and Maehr, Martin L., eds., Women in Science, Vol. 2 of Advances in Motivation and Achievement (Greenwich, Conn.: JAI Press, 1984). Shelf.

A compilation of very recent work on women in science. Many papers in the volume focus on the early education of boys and girls in science and mathematics. The papers most directly relevant to the problem of female scientists' productivity are by Cole and Zuckerman, and by Astin. See entries under these authors and under Kavrell and Petersen, Zerega and Walberg, Kremer, Harnisch, Eccles, Frieze and Hanusa, Benbow and Stanley, Humphreys, Steinkamp, and Grieb and Easley.

Technology Review, 87 (November/December 1984): 29-52; special section entitled "Women in technology." In file under "Tech. Rev."

See also references to Hornig, Traweek, Keller, Turkle, and Florman (this section).

Thompson, Julia, "Summary of the tenure committee survey," CSWP Gazette (A newsletter of the Committee on the Status of Women in Physics of the American Physical Society) , 4 (September 1984): 1-2.

Summary of study by Frieze, Thompson, and Baranger; see under Frieze (this section).

Traweek, Sharon, "High-energy physics: A male preserve," Technology Review, 87 (November/December 1984): 42-43. Under "Tech. Rev." in file.

A discussion of some of the personality traits common among high-energy physicists, and the difficulty with which women work in a community characterized by a dominance of such traits. This article is based on a book by Traweek entitled Buying Time and Taking Space: The Culture of the Particle-Physics Community.

Turkle, Sherry, "Women and computer programming: A different approach," Technology Review, 87 (November/December 1984): 48-50. Under "Tech. Rev." in file.

Discusses differences between boys and girls in approaching computer programming; suggests that girls' less analytic, more interactive style of programming has great value and should be respected.

Turner, Judith Axler, "Why more women than men shun computers," The Chronicle of Higher Education (October 10, 1984): 26.

Account of study that found women's aptitude for using computers as high as men, but their interest in doing so lower.

Tyler, Leona E., "Development of 'scientist' patterns of interest in boys," in Eiduson, Bernice T. and Beckman, Linda, eds., Science as a Career Choice (New York: Russell Sage Foundation, 1973): 285-292. Shelf.

Studies the development and personality correlates of boys designated as 'scientists' or 'nonscientists' on the basis of the Strong Vocational Interest Blank; does not compare boys with girls.

U.S. Congress, Office of Technology Assessment, Demographic Trends and the Scientific and Engineering Workforce: A Technical Memorandum (Washington, D.C.: USGPO, Dec. 1985). Shelf.

Includes a chapter entitled "Demographics and equality of opportunity," which in turn includes a section on women in science. This section summarizes several demographic studies on women (including ones by Berryman and Vetter, some of whose publications are listed in this bibliography). Topics include women's science education and "differential treatment of women in the...workforce."

Vetter, Betty M., "Working women scientists and engineers," Science, 207 (January 4, 1980): 28-34. WOM.

Abstract supplied by author: "About 80 percent of women trained in science or engineering are in the labor force, but many are employed outside of their fields. Most who withdraw from the labor force do so temporarily, and about half do not take a career break even when they have small children. Factors affecting labor force participation are student status, highest degree level, parental status and age of children, and field of degree. Employment opportunities are restricted in some fields, and women have higher unemployment rates and lower earnings than men..."

Welch, Michael R. and Lewis, Stephen, "A mid-decade assessment of sex biases in placement of sociology Ph.D.s: Some evidence for contextual variation," American Sociologist, 15 (August 1980): 120-27.

The authors attempt to assess the effects of affirmative action on hiring of new faculty in sociology departments. They find that gains have been made by women, but that discrimination still exists in the most prestigious departments.

Widom, Cathy Spatz and Burke, Barbara W., "Performance, attitudes, and professional socialization of women in academia," Sex Roles, 4 (August 1978): 549-62.

Investigates social psychological factors related to male-female productivity differences and other aspects of academic life. The authors conclude that "(d)ifferences in the early socialization of men and women may result in the differential professional socialization of female faculty. Subtle areas of sexual discrimination in the academic experience are suggested" (emphasis in the original). The authors do not reveal the departmental affiliations of their subjects.

Wiegers, Rebecca M. and Frieze, Irene Hanson, "Gender, female traditionality, achievement level, and cognitions of success and failure," Psychology of Women Quarterly, 2 (Winter 1977): 125-37.

Attempts to ascertain the effects on the experience of succes or failure of gender, previous achievement level, and, with women, traditional or nontraditional outlooks (the latter being defined by college and career aspirations).

Zarega, Margaret E. and Walberg, Herbert J., "School science and femininity," in Steinkamp, Marjorie W. and Maehr, Martin L., eds., Women in Science (Greenwich, Conn.: JAI Press, 1984): 37-50. Shelf.

Studies the attitudes of young adolescent boys and girls toward science; proposes educational approaches to encourage girls' interest in science.

Zuckerman, Harriet and Cole, Jonathan R., "Women in American science," Minerva, 13 (Spring 1975): 82-102.

An early summary of research on the obstacles which women face in attempting to enter the scientific profession. Proposes that women scientists are "triply handicapped: first by having to overcome barriers to their entering science, second by the psychic consequences of perceived discrimination--limited aspiration--and third by actual discrimination in the allocation of opportunities and rewards."

Appendix

The following books and papers were brought to the compiler's attention after the body of the bibliography was completed. The section in which the work should appear is indicated to the left of each set of references.

I.A. Garfield, Eugene, "Is citation analysis a legitimate evaluation tool?" Scientometrics, 1 (1979): 359-375.

Pinski, G., "Citation based measures of research interactivity," Scientometrics, 2 (1980): 257-263.

I.B. Boor, M., "The citation impact factor: Another dubious index of journal quality," American Psychologist, 37 (1982): 975-977.

I.C. Small, Henry G., "Cited documents as concept symbols," Social Studies of Science, 8 (1978): 327-340.

II. Creswell, J.W., Faculty Research Performance: Lessons From the Sciences and the Social Sciences (Washington, D.C.: Association for the Study of Higher Education, 1985).

Hunter, J.E., Schmidt, F. and Jackson, G., Meta-Analysis: Cumulating Research Findings Across Studies (Beverly Hills, Calif.: Sage, 1982).

Mahoney, M.J., "Publication prejudices: An experimental study of confirmatory bias in the peer review system," Cognitive Therapy and Research, 1 (1977): 161-175.

Martin, Ben R., Irvine, J., Peacock, T. and Abraham, J., "A re-evaluation of the contributions to radio astronomy of the Nancay Observatory, 4S Review (Society for the Social Studies of Science), 3 (1985): 4-18; accompanied by comments by Gillmor and Gouguenheim.

VIII.D. Boruch, R.F., Wortman, P.M. and Cordray, D.S., eds., Reanalyzing Program Evaluations (San Francisco: Jossey-Bass, 1981).

Cook, T.D., Leviton, L.C. and Shadish, W.R., "Program Evaluation," in G. Lindzey and E. Aronson, eds., Handbook of Social Psychology, 3rd ed. (N.Y.: Random House, 1985): 699-777.

Cook, T.D. and Shadish, W.R., "Metaevaluation: An assessment of the congressionally mandated evaluation system for community mental health centers," in G.J. Stahler and W.R. Tash, eds., Innovative Approaches to Mental Health Evaluation (N.Y.: Academic Press, 1982).

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Cook, T.D. and Shadish, W.R., "Program evaluation: The worldly science," Annual Review of Psychology, 37 (1986): 193-232.

House, E.R., Evaluating With Validity (Beverly Hills, Calif.: Sage, 1980).

Rossi, P.H. and Freeman, H.E., Evaluation: A Systematic Approach, 3rd. ed. (Beverly Hills, Calif.: Sage, 1985).

Scriven, M.S., The Logic of Evaluation (Inverness, Calif.: Edgepress, 1980).

Shadish, W.R., "Sources of evaluation practice: Needs, purposes, questions, and technology," in L. Bickman and D.L. Weatherford, eds., Evaluating Early Intervention Programs for Severely Handicapped Children and their Families (Austin, Texas: Pro-Ed, 1986).

IX. MacRoberts, M.H. and MacRoberts, B.R., "Communication in science," Social Studies of Science, 16 (1986): 151-172.